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SORGHUM NEWSLETTER

Volume 4

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The support of Frontier Hybrids and the Rockefeller Foundation is also acknowledged for Volume 3.

A very few copies of Volume 3 remain and will be sent upon request. Several lengthy tables have been omitted from articles in this volume.

W. M. Ross, Editor
Ft. Hays Branch
Kansas Agricultural Experiment Station
Hays, Kansas
April 15, 1961

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I. CONTRIBUTIONS

ALABAMA

Sorghum and Sudangrass

C. S. Hoveland (Auburn)

Grass sorghums

During 1960 over 50,000 pounds of *Sorghum almum* seed were sold by seed wholesalers in Alabama. Research to date indicates that it is adapted as an annual throughout the state but that annual production is no better than pearlmillet. Dry matter yields in tons per acre (average of seven locations) in 1960 were: Gahi-1 millet - 4.40, *Sorghum almum* - 4.05, DeKalb SX-11 - 3.77, Sweet sudan - 2.80.

Sorghum almum stands have been seriously depleted in the spring of the second year but tend to thicken by summer making good total production. However, by the third year stands are eliminated. Yields over a three-year period are shown in table 1. Drought reduced yields of Johnsongrass in 1960, but stands of this grass remained intact. Stands of perennial sweet sorgrass also were eliminated by the third year.

Table 1. Forage production of sorghum grasses at Tallassee, Alabama, over a three-year period. Planted May 1, 1958.

Species	Tons per acre oven dry forage 1958	1959	1960
Commercial Johnsongrass	2.45	5.94	1.89
Sorghum almum	3.88	5.52	0.28
Perennial Sweet Sorgrass	4.62	5.47	0.00

The Sorghum x Sudan crosses, Asgrow Grazer-W and DeKalb SX-11, have given yields at some locations equal to that of pearlmillet. In addition, these sorghums have continued producing during the critical fall months when millets cease growing.

Four Sudangrass hybrids (9901, 9902, 9907, and 9908) from Chillicothe, Texas, performed unusually well during 1960 in south Alabama. Texas 9907 yielded 3.42 tons of dry forage as compared with 1.77 tons for Piper and 2.07 tons for Georgia 337. The hybrids had much better seedling vigor and made much more early growth than other varieties. Disease resistance was good. Although yields of the hybrid sudans were good, pearlmillet yielded two to three times as much.

Silage sorghums

Sorghum for silage is a new crop in Alabama, but acreage is increasing. Corn silage yields are often sharply reduced by drouth. Silage tests with 12 to 20 varieties were conducted at 5 locations in 1960. Sart, Asgrow Beefbuilder

and Lindsey 115F were three of the most productive varieties. Dry matter yields of over 10 tons per acre were obtained at two locations. Lodging has been a serious problem with Sart, and grain content is low. Separation of sorghum varieties into plant parts (table 2) showed that several high yielding varieties also made good grain production. Yields were severely reduced on the first cutting by drouth.

Table 2. Yield, percentage of plant parts, and sugar content of several sorghum varieties of first harvest at Tallassee, Alabama, 1960.

Variety	Oven-dry forage, tons per acre1/	Percentage of oven-dry material: head	stalk	leaves	Percent sugar in stalk juice
Sart	6.86	5.1	73.0	21.9	14
Asgrow Beefbuilder	6.75	26.4	58.2	15.4	16
Lindsey 115F	5.91	15.4	58.8	25.8	13
NK-320	4.30	35.4	33.3	31.3	6
NK-300	3.26	48.6	28.9	22.5	7
L.S.D. 5%	0.96				3.4
C.V. %	14.7				22.1

1/ Each variety harvested when seed were in the hard dough stage.

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ARGENTINA

Information for the 1961 Sorghum Newsletter

Ricardo Parodi (Manfredi, Cordoba)*

In Argentina in 1960-61, approximately 1,900,000 hectares of different sorghums were cultivated. This was composed of 730,000 hectares of grain sorghum; 556,100 of sudan grass; 318,700 of sweet sorghum; 260,500 of Sorghum almum, and the remainder of miscellaneous sorghums.

Understandably, grain sorghum occupied the primary acreage, having increased considerably in area the last 10 years. The increase has been from 37,000 hectares in 1950-51 to the acreage indicated above.

The increase in grain sorghum is related especially to the increase in cattle breeding, livestock feeding, and milk production as well as to the growing interest in grain for industry and for exporting. Finally, it has acquired importance in the area where cultivated in the rotation with peanuts. Basically it is a crop that is easily and dependably cultivated; furthermore, it has the double advantage of having grain valued for feeding and for industry. It can be used directly for planting and is noted for its drought resistance and ability to remain green during dry periods. This application has much importance in the province of Cordoba where semi-arid conditions predominate.

*The editor assumes responsibility for all errors in translation from the Spanish.

The major concentration of the grain sorghum area is found in the province mentioned. It has 38.3 percent of the total with a production of 280,000 metric tons from 45.8 percent of the counties.

The varieties that one finds principally in Cordoba are Early Kalo, Martin, Plainsman, Westland, Combine Kafir-60, and Pergamino Feterita. They have demonstrated good adaptation to the climate and altitude for grain production. Except for the last variety which was obtained from the Pergamino Experiment Station, they are adaptations of different introductions from the U.S.A., coming from different official institutions in past years. Recently a range of commercial hybrids has been collected for distribution.

The importance acquired by grain sorghum and the great concentrated cultivation in Cordoba has caused the Manfredi Experiment Station to undertake work relating to the crop. In 1948 a collection of species, varieties, and derivatives of sorghum was initiated. These were accumulated gradually and now amount to 1052 entries and were grown this year for small increases. Most of those retained are early, have firm seed, and have yield ability, determined after many years of selection and observation in the breeding program. All of them are actually being increased for possible future distribution.

In 1955 the first crosses were made. A promising one is Early Kalo x Spur Feterita, now in the F6. This program will continue into future years.

In 1957 through the courtesy of U. Rosbaco of Argentina and O. A. Knott, A. J. Casady, J. R. Quinby, and R. F. Holland of the U.S.A., there arose the opportunity to incorporate new breeding material from six lines carrying the male-sterile character. Eleven experimental hybrid combinations were made in the field in the summer of 1958, and in the following year reaction of distinct lines to the male-sterile character was established and proved. In the summer of 1959, 104 combinations were studied, 22 of which were tested in a 5 x 5 balanced lattice, and 13 others were tested similarly in a 4 x 4 lattice. Early Kalo, Martin, and Plainsman were used as checks in both tests. The remaining hybrids were grown in observation plots only because of limited seed.

From observing the hybrids, it was found that 64 lines recovered fertility, 27 were totally male sterile, and 4 were partially male sterile. During the present summer (1960) 163 hybrid combinations were made.

The objectives of the grain sorghum breeding program are the derivation of early, high yielding varieties or hybrids, having sound seed, resistance to corn stalk borers (Diatraea sp.), resistance to sprouting in the head, and adaptation to mechanical harvest that does not destroy the stubble cover.

J. L. Scantamburlo and F. O. Martinez cooperated in this work.

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ARIZONA

Interrelationship of Sorghum Varieties and Nutrients

Lee S. Stith (Tucson), H. F. Kreizinger (Yuma) and J. L. Abbott (Mesa)

Three hybrids and one variety were grown in four locations in Arizona for a two-year period. The hybrids ranged from early to late maturity (RS 501, RS 610, and Tx 660) and the environment from hot and dry (Yuma) to the more ideal for sorghum which is in the higher altitudes (near 4,000 ft.) in the southeast corner of the state. Superimposed on the variety tests were nine fertilizer treatments including 0 to 240 pounds of actual nitrogen per acre and then these in combination with phosphate.

The objectives of the experiment were to measure yield responses of the hybrids and standard variety, and to study the components of yield. The experiment can be summarized as follows:

1. Hybrids generally outyielded the standard.
2. No interaction between fertilizer and the varieties were observed.
3. The fertilizer apparently did not change the number of heads per unit area.
4. There were significant differences in weight per head.
5. There were no significant differences between seed volumes as they were measured.
6. There was relatively little variation in the weight per 500 seeds.
7. Therefore, the differences in yield were found to be due to the number of seeds per head.

This study poses two questions: (1) for the plant breeder, selection should be toward heads with largest grain potential, and (2) for the agronomist, apply fertilizer and water (under irrigation) early enough in the life of the plant to affect primordial differentiation.

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AUSTRALIA

Hybrid Sorghum in Queensland

R. F. Moore (Warwick)

The first seven Queensland trials to contain hybrid sorghum were grown last year and the results have been published in the Queensland Agricultural Journal (October, 1960). Yield data obtained follow:

Strain	Herm-itage	Bil-oela	Mt. Tyson Early planted	Mt. Tyson Late planted	Law-es	King-aroy	War-wick	Mean (all trials)	Increase over Alpha
				Location					
				Yield - bushels per acre					%
Hybrids									
Texas 601	113	46	75	72	83	62	25	68	26
RS 610	112	61	78	76	95	73	36	76	41
Texas 620	133	39	69	64	91	70	27	70	31
RS 630	113	51	72	79	92	76	31	73	36
Texas 660	125	50	71	72	94	68	32	73	35
C.Kafir-60 x Alpha	119	51	--	74	--	67	30	68	45*
Martin x Alpha	103	55	--	66	--	68	30	64	37*
Martin x Caprock	113	56	66	60	75	64	29	66	23
Varieties									
Alpha	81	37	60	50	82	50	17	54	--
Early Kalo	74	33	51	57	80	--	16	52	--
L.S.D. (.01)	14	15	11	18	7	17	14		
(.05)	10	11	8	13	5	12	10		

*Five trials.

The two leading varieties, Alpha and Early Kalo, were out-yielded in each trial at the 1% level by RS 610 and RS 630, except in one instance where RS 630 reached the 5% level only. The hybrids as a group averaged 31% more grain than did Alpha.

Trials last year were grown under good rainfall conditions, but current trials have been hit by a severe drought. Last year the maturity range covered by the hybrids was very narrow and extended from early to mid-season. This year marked differences in maturity are evident. RS 608, RS 610, and RS 630 show earliness in maturity (which is highly desirable) while Texas 620, Texas 660, and the Alpha hybrids are behaving as late hybrids.

In only one trial so far has charcoal rot been prevalent. Lodged heads were harvested separately. The weight of grain from these lodged heads is expressed as a percentage of total grain from each strain as indicated:

Strain	Grain on lodged heads (Lawes trial)
	%
Alpha	trace
Early Kalo	1
Texas 601	5
RS 610	6
Texas 620	10
RS 630	5
Texas 660	13
Martin x Caprock	39

This rot has taken a heavy toll in commercial crops this year, and I would be pleased to receive news of any highly resistant material. Midge also is a very real menace in Queensland.

Sudangrass and undesirable Sorghum vulgare pollen are showing up as a much greater nuisance in crossing plots then has been the case in fields to produce seed of varieties. Sudangrass pollen blew 60 chains to a crossing plot last year and has resulted in approximately ten grass hybrids per acre in fields sown with seed from this crossing plot. We feel that increasing the isolation distance (at present 40 chains) will be a last resort and intend to first try growing a border 20 feet wide of pollen parent on all sides of the crossing plots.

Seed set in crossing plots has been good except in two instances - in both instances the crop was showing moisture stress at flowering time. Although flowering times of parents were similar and seed set on the restorer parent is very high, seed set on male-sterile heads is estimated at only 5%. Seed set on male-sterile heads flowering at the same period but in neighboring fields with better moisture reserves have well-filled heads. I feel that under conditions experienced this year in Queensland that moisture stress within the plant may have resulted in greatly shortened stigma life and may account for the low seed set.

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BRAZIL

Comments on Sorghum in Northeast Brazil

Mario Coelho de Andrade Lima (Recife, Pernambuco)

Sorghum introductions

It is generally accepted that sorghum was introduced into Brazil in the 18th or 19th centuries by African slaves. Even today, the grain harvested in small and scattered plantings is named Guinea corn.

From this origin a few nuclei were established some of which are varieties or strains having special characteristics and uses. On such variety is the "caninha" in Piaui State, used for chewing in the same way that sugar cane stalks are sometimes used. In the Rio Grande do Norte State, the durra variety is grown in the Acu River Valley for human food, especially as flour to be mixed with imported wheat flour. Another recent introduction was Grohoma, which received great world publicity. For reasons not well known, Grohoma was not a very successful variety and now is grown only in experimental stations as a novelty.

A few years ago the Ministry of Agriculture's Alagoinha Experimental Station located in Paraiba State received a variety collection from the Rockefeller Commission in Mexico which included the varieties Redbine, Shallumex, Caprock, two Kafirs, Hegari temprano, Hegari dobleano. The I.C.A., through ETA, obtained new introductions in 1958 from the Nebraska Experimental Station, Fort Hays Experimental Station in Kansas, Woodward Experimental Station in Oklahoma, and Chillicothe and Lubbock Experiment Stations in Texas. The seeds from more than 500 varieties and hybrids came to Northeast Brazil by request from Brazilian Technicians that received scholarships from the I.C.A. in these Experimental Stations.

Among the introduced varieties, those from Nigeria and Sudan received through the Nebraska Experiment Station merit special attention. In the observation plots of these varieties in the ETA Project 40 headquarters at Recife, some are very promising for grain production, others for forage or dual-purpose use. Many are very rich in sugar. More of them are very good ratoon producers, a characteristic lacking in the American varieties introduced at the same time. In this planting 6 ratoon harvests already have been made of selections of African origin, and the ratoon growth continues to produce more than was obtained in the first harvest after planting.

Grain sorghum

Encouraged by the good performance and adaptation shown by introductions of sorghum varieties from the Rockefeller Foundation at the Alagoinha Experiment Station, the State of Pernambuco started experimental work with sorghums in 1957. These studies were made in those Pernambuco stations located in regions of deficient and poorly distributed rains but where corn is generally grown. A typical station in the region is at Serra Talhada, where in a five year period only one good corn crop is harvested, two of these years produce a poor crop and a crop failure occurs the remaining two years. After four years of research, the evidence showed that sorghum produces two times more grain than corn. At those locations with more favorable conditions for corn, the yield of corn was greater than that of sorghum during good years. However, when it was impossible to plant the test comparison of corn and sorghum in the beginning of the rainy season, or when the planting failed, the sorghum yield was greater than that of corn. Even though these experiments show that sorghum has several advantages over corn in the semi-arid areas of the Northeast, the diffusion of sorghum has been very slow or nil. The assumed reasons for this slow acceptance are as follows:

1. Delayed diffusion of experimental results.
2. No market for the pioneer plantings.
3. No good machinery in the region for planting and cultivation.
4. No threshing machinery.
5. Bird damage.
6. Weevil attack in open storage.
7. Loss of germination power when the seeds are stored in closed bins.

Forage sorghum

Some research has been made in comparing corn silage production with the sorghum silage. In the area where the tests were done, the green and dry production from the corn was higher in the first cutting, but with the addition of the ratoon sorghum production the total production from sorghum was more than that from corn.

The environmental adaptation of sorghum permits it to make a complete vegetative life cycle within a growing season too short for corn. Qualitatively, the forage of sorghum had a higher content in protein, carbohydrates and fats than corn. Results from a typical experiment made in 1960 at the Cedro Experiment Station, planted after the middle of the rainy season, are shown in table 1.

Table 1. Corn silage vs. sorghum silage.

Corn	1st cutting %	1st cutting lb./acre	2nd cutting %	2nd cutting lb./acre	Total lb./acre
Green fodder	-	20,900	-	0	20,900
Dry matter	-	5,225	-	0	5,225
Crude protein	4.08*	213	-	0	213
Fats	1.04*	54	-	0	54
Fiber	25.26*	-	-	-	-
Sumac sorghum					
Green fodder		16,700	-	7,400	24,100
Dry matter		4,509	-	2,368	6,877
Crude protein	5.50*	248	5.50**	130	378
Fats	2.52*	114	2.52**	60	174
Fiber	19.31*	-	19.31**	-	-

* Analyses made by the Acordo Fomento Prod. Animal.
**The analyses were made of first cutting only, these values being applied to both cuttings for computation purposes.

Similar results were found in three other experiments made at the Alagoinha Experiment Station, Pa; the Surubim Experiment Station, Pe; and the Peixe Farm in Pesqueira, Pe. It is believed that the sorghums in these tests will produce additional cuttings in the next rainy season.

The varieties from Nigeria and Sudan that have produced much more than the Sumac probably will show in the future even more favorable for sorghum than was found in these comparisons of corn with sorghum. Many of the American varieties are not good ratoon producers because they are injured by a dry rot in the stalks. Some grain varieties are attacked even in the first crop by a disease that looks like the milo-disease from a Giberela-Fusarium.

Sudangrass

The ETA Project 40 technicians have given much attention to sudangrass. It has been quite successful in the State of Rio Grande do Norte where the common sudan has given good production.

In the wetter area, only the varieties Piper and Greenleaf show some promise because of their rust resistance. Nonetheless, it is not believed that they could compete with the Napier or Merker grass.

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CHINA (TAIWAN)

A Yield Trial of Hybrid Sorghum

C. P. Pi (Taipei)

A yield trial of twelve cross combinations of male-sterile Combine Kafir-60 with commercial varieties was conducted at the University Farm, Taipei, Taiwan,

China, in the fall of 1959. The field layout was in randomized blocks with four replications. The data are summarized in table 1.

Table 1. Summary of yield trial of male-sterile Combine Kafir-60 x varieties.*

Cross combinations	Date heading	Plant height (cm)	Sorghum borer injury %	Av. yield (gm)**
m.s. x Hegari	Oct. 8	272.5	37.18	137.80
m.s. x Shallu	Sept. 26	219.8	4.70	72.21
m.s. x Combine 7078	Sept. 29	120.5	35.71	59.66
m.s. x Shallu (Taichung)	Oct. 4	117.3	6.97	45.71
m.s. x Martin	Sept. 28	114.3	6.89	42.94
m.s. x Caprock (S.A. 7000)	Sept. 22	109.5	7.96	41.57
m.s. x Westland	Sept. 23	109.3	17.44	40.94
m.s. x Coastland	Sept. 21	111.6	2.41	34.71
Westland	Sept. 22	98.6	32.18	30.51
m.s. x Kafir 1	Oct. 4	113.3	7.14	23.18

*Planting date - July 22, 1959 L.S.D. 0.05 = 17.62
**Average yield of single plant 0.01 = 23.78

The average yield of single plants of m.s. x Hegari was 137.80 and m.s. x Shallu was 77.21. Both are significantly superior to either male parents (Hegari, 64.45 gm and Shallu, 50.22 gm) or the recommended variety, Westland (30.51 gm). Unfortunately, the highest producing cross combinations, m.s. x Hegari and m.s. x Shallu, were tall and late maturing, which is not satisfactory for sorghum growers in Taiwan where typhoons hit the island frequently during the growing season.

The data also indicated that the percentage of sorghum borer injury varies among cross combinations which is closely related to the parental variety in the crosses (the data of parental varieties are not given in the above table). Sorghum borer resistance seems not to be related to plant height and maturity. It is determined probably by the stiffness of stalk.

Seed setting of m.s. x Martin, m.s. x Westland, m.s. x Coastland and m.s. x Kafir 1 is very poor, since the F1 progenies of these cross combinations are male sterile. The other three cross combinations, m.s. x Redbine, m.s. x R 7000 and m.s. x Midland, with one or two missing plots are not presented in the table. The average yield of these three cross combinations was not desirable.

The Inheritance of Cytoplasmic - Genetic Male Sterility in Sorghum

C. P. Pi and K. D. Wu (Taipei)

Using male-sterile Combine Kafir-60 as the female parent, fifteen cross combinations were made in 1959. All the materials, parents, F1, F2 and backcross progenies of male-sterile Combine Kafir-60 x F1 were planted at the same time in the spring of 1960. Parts of panicles were collected and stored in 70-percent alcohol. All materials were checked cytologically to determine pollen fertility. Plants completely free from normal pollen were classified as sterile plants.

In the F1 progenies, m.s. x Westland, m.s. x Kafir, m.s. x Coastland and m.s. x one indigenous kaoliang variety (S. vulgare var. Nervosum) were completely male sterile. It is assumed that these varieties have a male-sterile gene identical with the male-sterile Combine Kafir-60 gene.

The results of F2 and BC1 progenies are summarized in table 1.

Table 1. Summary of pollen sterility of F2 and BC1 progenies of male-sterile Combine Kafir-60 x varieties. The P values from the X2 test for goodness of fit to the hypothesis of single independent factor pair are included.

Cross combinations	Generation	No. total plants	No. fertile plants	No. sterile plants1/	P value
m.s. x Caprock	F2	54	39	15	0.5-0.7
(Taichung)	BC	99	45	54	0.3-0.5
m.s. x Combine 7078	F2	27	20	7	0.9-0.95
	BC	26	13	13	0.99
m.s. x Hegari	F2	21	17	4	0.3-0.5
	BC	68	41	27	0.05-0.1
m.s. x Shallu	F2	92	69	23	0.99
(Taichung)	BC	96	58	38	0.02-0.05*
m.s. x Caprock 7000	F2	96	71	25	0.98-0.99
	BC	96	41	55	0.1-0.2
m.s. x Redbine	F2	83	49	34	< 0.01**
	BC	98	43	55	0.2-0.3
m.s. x Arizona	F2	46	41	5	0.02-0.05*
	BC	71	52	19	< 0.01**
m.s. x Shallu	F2	93	59	34	0.01-0.02*
	BC	89	66	23	< 0.01**
m.s. x R 7000	F2	51	49	2	< 0.01**
	BC	95	63	32	< 0.01**

* Significant P value
**Highly significant P value
1/ No normal pollen formed

From the data of F2 and BC1 progenies, the segregation of cross combinations, m.s. x Caprock (Taichung), m.s. x Combine 7078, m.s. x Hegari, m.s. x Caprock 7000, and m.s. x Shallu (Taichung) satisfactorily fit the basis of a single pair of recessive genes interacted with sterile cytoplasm as Maunder and Pickett2/ reported. The ratios of m.s. x Arizona and m.s. x R 7000 agree very closely with an expected 15:1 ratio in the F2 and 3:1 ratio in backcross progenies, assuming two independent recessive genes are in effect. The ratio of the other two combinations, m.s. x Redbine and m.s. x Shallu, are not explained on a simple hypothesis.

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COLORADO

Colorado Sorghum Experiments in 1960

Warren H. Leonard (Ft. Collins), Herbert O. Mann (Springfield), Jerre Swink (Rocky Ford), and Floyd W. Frazier (Akron)

Sorghum experiments in Colorado in 1960 involved various yield tests of grain sorghum and sorgo varieties conducted in eastern Colorado under dryland conditions at Akron and Springfield as well as under irrigation at Rocky Ford. Sorghums in dryland tests generally produced low yields because of hot dry weather in July and August. There was little effective rainfall until September.

2/ Maunder, A. B. and Pickett, R. C., Agron. Jour. 51: 47-49. 1959.

A study of 65 early grain sorghum lines, selected at Akron over a period of years, was continued at Rocky Ford in 1960. Tests indicated that 13 of these lines were fertility restorers. Nine restorers, crossed on various male-sterile lines in 1959, were as follows: Ak 9-2, Ak 10-1, Ak 11-1, Ak 23-1, Ak 25-3, Ak 26-4, Ak 28-1, Ak 43-1, and Ak 51-1. The male-sterile parents used were Combine Kafir-60, Martin, Coes, Reliance, and Westland. A total of 28 Akron-line hybrids, together with suitable checks, were tested for yield in 1960 at Rocky Ford, Springfield, and Akron.

Under irrigation at Rocky Ford, the acre yields in bushels for the 5 high hybrids out of 34 entries were as follows: Martin x Ak 9-2, 102.7; RS 610 (check), 102.3; Reliance x Ak 28-1, 101.5; Combine Kafir-60 x Ak 28-1, 101.3; and Martin x Ak 10-1, 100.8. None of these hybrids differ significantly in yield. All Akron-line hybrids in this test showed from 25 to 50 percent of lodging, except for Combine Kafir-60 x Ak 28-1 which lodged only 1.2 percent as compared with 6.7 percent for the RS 610 check. The high Akron-line hybrids matured 2 to 7 days earlier than did RS 610.

Yield results with Akron-line hybrids under dryland conditions at Springfield indicate that several offer promise for southeastern Colorado. Data for the 5 high hybrids and the RS 608 check are as follows:

Rank	Hybrid	Date bloom	Date mature	Plant height (in.)	Test weight (lb.)	Grain yield per acre (bu.)
1	Coes x Ak 43-1	7-26	9-3	28	58.6	41.5
2	Combine Kafir-60 x Ak 43-1	7-31	9-7	30	58.6	38.4
3	Martin x Ak 43-1	8-2	9-7	27	58.9	32.6
4	Reliance x Ak 10-1	8-2	9-9	28	57.7	29.1
5	Martin x Ak 23-1	8-7	9-16	25	58.6	28.0
27	RS 608 (check)	8-3	9-23	19	58.5	17.2
	L.S.D. (0.05)					5.3

The RS 501 check matured on September 14, yielded 18.5 bushels, and ranked 24th. In the same test, RS 610 matured on September 20, yielded 14.0 bushels, and ranked 30th. The Akron-line hybrids produced relatively high yields in spite of the drought.

All grain sorghum yields at Akron were low in 1960. Yields of the 5 high Akron-line hybrids, in comparison with the RS 608 check, were as follows:

Rank	Hybrid	Date bloom	Plant height (in.)	Test weight (lb.)	Grain yield per acre (bu.)
1	Martin x Ak 43-1	8-5	36	56.0	7.8
2	Combine Kafir-60 x Ak 43-1	8-5	40	55.0	6.9
3	Coes x Ak 43-1	8-3	36	55.5	6.8
4	Reliance x Ak 51-1	8-9	31	53.5	5.2
5	Westland x Ak 25-3	8-17	33	55.0	4.6
17	RS 608 (check)	8-13	31	55.5	3.3
	L.S.D. (0.05)				3.3

The RS 610 check ranked 22nd with a yield of 2.8 bushels while RS 501 ranked 29th with 2.1 bushels.

In both dryland tests, the three highest yielding Akron-line hybrids had Ak 43-1 as a parent. It is a selection from a Reliance x Early Kalo cross. The results indicate that several Akron lines are valuable parent material for hybrids grown under hot dry conditions in eastern Colorado. Some of the Akron-line hybrids yielded well under irrigation at Rocky Ford, but none significantly outyielded RS 610. The most satisfactory hybrid was Combine Kafir-60 x Ak 28-1, which matures at about the same time as RS 610. The Ak 28-1 line involved was a selection from pink-seeded Coes.

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DE KALB AGRICULTURAL ASSOCIATION

A. B. Maunder (Lubbock, Texas)

Charcoal rot studies

Charcoal rot, a stalk rot caused by the soil-borne fungus, Macrophomina phaseoli, is the most destructive sorghum disease in the United States. On sorghums it is most common in the areas of high temperature and low moisture stress. Although lodging and disintegrated pith with sclerotial formation are the most common symptoms, less common symptoms are seedling blight, root lesions, discoloration of the stalk and occasionally upper node breakage.

Two nurseries were established in 1960 to screen lines and hybrids in hopes of finding resistance. The grain test included 323 single-crosses and three-way hybrids and 377 varieties and strains. The forage test was represented by 34 hybrids and 86 varieties and strains. This made a total of 820 entries which were replicated three times at Lubbock, Texas, and Texico, New Mexico. The New Mexico test was on land with a high natural buildup of the organism. Three isolates were used to build up inoculum on half toothpicks. Readings were made by cutting the stalks radially and measuring the upward movement of the organism in centimeters.

A total of 18 readings for each of 700 grain entries at Lubbock resulted in a range of mean values from 1.3 cm. to 27.2 cm. The Lubbock total average infection was 9.8 cm. whereas Texico averaged 6.4 cm. Conditions this particular year were more favorable for disease development at Lubbock. The frequency distribution of entry averages was as follows:

Growth of fungus cm.	No. of entries Lubbock	No. of entries Texico
0 - 2.9	22	149
3 - 5.9	123	218
6 - 8.9	169	177
9 - 11.9	153	82
12 - 14.9	132	41
15 - 17.9	64	20
18 - 20.9	19	7
21 - 23.9	5	1
24 - 26.9	1	-
27 - 29.9	1	-

At Lubbock the varieties and strains averaged 7.8 cm. as compared to 11.9 cm. for the hybrids. As a rule the hybrids were more severely infected than the mean of the parents and often more than the most susceptible parent. With susceptibility acting as a dominant this relationship would be expected if resistant parents were limited.

Based on the Lubbock test, which was the better grain test, several lines appear to show promise of genetic resistance. Some entries gave indications of resistance by mechanical exclusion and/or internal structural barriers. Tolerance to the disease may be another source of improvement. This ability of endurance was illustrated by both inoculation tests as well as larger field plantings. The better lines found in the screening program will be further tested with field inoculations and also by the greenhouse screening technique developed by Dr. David C. H. Hsi.

The three isolates used seem very likely to be genetically different in regard to cultural and pathogenic characteristics. Growth in artificial media is not an indicator of field activity. Variance within an entry seemed too great to justify any conclusions about reactions of any one entry to the three isolates.

Although the forage tests were not as informing, evidence of variable reactions to the organism were present. None of the entries would appear to carry a better type of resistance than was found in the grain types.

Except for the Texico forage, there was a significant negative correlation between days to heading and average charcoal rot development. All of the more resistant entries were not, however, of late maturity.

Correlation values between days to heading and average infection at Texico and Lubbock.

Test	DF	r	R^2
Texico grain	694	-.08*	.01
Lubbock grain	689	-.17**	.03
Texico forage	117	-.12 N.S.	.01
Lubbock forage	110	-.29**	.08

byx = 0.16 for Lubbock grain

As shown by the R^2 values, the percent of variation in the readings which may be attributed to the variation in maturity is quite low. The regression coefficient for Lubbock grain indicates a day later in maturity resulted in 0.16 cm. less disease development.

Results obtained at the Clovis and Lubbock substations in addition to these encourage continued testing and efforts to work resistance into agronomically desirable lines. A wide geographical range of isolates will be tested against the better material.

Effect of location on sterility

There appears to be a considerable location effect on the action of the cytoplasmic sterility nuclear factors or even possibly the action of the sterile cytoplasm. Lines which could be sterilized in Indiana might be all partial fertile at Lubbock, Texas. To get a better check on this idea, seed from an F5 population at Lafayette, Indiana, was grown at Lubbock as an F6. This particular pedigree had a history of low fertility from the F2 through the F5.

Forty plants were tested in the F6 population by percent viable pollen based on a potassium iodide stain. As found with large population tests, this type of reading will give a lower fertility level than percent seed set. The distribution of the 40 plants in percent viable pollen was as follows:

Steriles	1-4	5-19	20-39	40-59	60-79	80-94	95-100
0	0	2	6	5	17	10	0

Now comparing this data with the F2 to F5 data at Lafayette, Indiana, a significant fertility increase exists in the F6.

% Seed Set

F2	F3*	F4	F5**	F6***
2	2	5	3.4	62.5

* On tiller
** F5 mean
*** All readings but the F6 are in percent seed set whereas the F6 is in percent viable pollen.

Two definite differences were present in this F6 data. First, the phenotypic expression had considerably more variance than it had in previous generations. Second, the fertility level was very high in the F6 at Lubbock, whereas in the preceding four generations at a lower latitude, this particular entry has consistently remained low. Therefore, to develop a useable sterile for this area requires that the modifying complex be considered as well as the major gene or genes.

Gametocides

Observations of a weed control plot at Purdue University in 1959 suggested that aminotriazole, when applied as a post emergence spray, gives sterility at a certain concentration. This being the case, it should be possible to spray a nursery row of a fertile line and produce a male-sterile row at pollination time.

Three replications of three varieties and two hybrids were planted in 4 row plots, 10 feet in length. The varieties were of early, medium and late maturity: Reliance, Martin and Caprock. The hybrids were E-56a and RS 610. Treatments of 0, 2, 4, and 6 pounds were applied 4 weeks later when the whorl was approximately seven inches high. In general the chlorotic effects of the spray treatments showed a direct relationship with the rate of application. Reliance showed the greatest effect although no plants showed visible effects of the spray at flowering.

Twenty plants in each plot were bagged at flowering. Seed set was similar for both the heaviest rate of application and for the checks of the hybrids with some partials showing in the highest rate of the varieties. No sterility of the degree required for practical use in the breeding program was observed. Since the heavy rate had a severe effect soon after spraying, the time of application rather than rate should possibly be altered with a spray nearer flowering.

Combining ability test

The use of a double-cross to estimate general combining ability in grain sorghum was investigated this past summer. It consisted of (A x B) x (A x R) parents. Therefore only part of the plants were sterile for easy crossing. The test gave a fairly accurate placing at the high and low ends based on the known performance of eight common restorers. The R line in the double-cross was also one of the lines tested and consequently one-fourth of such test plants actually were sibs. This no doubt lowered its performance.

Future double-crosses will be (A x B) x (B x B) with a hot water cross required in the pollen single-cross. This should theoretically give 100% steriles in the tester and also allow testing against a B-line germ plasm pool.

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FRANCE

Plant Breeding Station of Montpellier

S. Rautou (Montpellier)

Until recently grain sorghum was not cultivated very extensively in France, but the coming of new conditions - a low price sorghum as compared with corn, American hybrid introductions, and chemical weed control- will perhaps modify this situation.

Two grain sorghum performance tests were located at Montpellier in southern France in 1959 and 1960 under irrigated conditions. The highest yields in 1959 were produced by RS 590, Wheatland x Redbine-60, Tx 660, and RS 610 at 95.7, 94.8, 93.6, and 92.9 quintals per hectare. RS 590 yielded 18.7% more than the standard variety, Combine Kafir-60. The superiority of the top yielding hybrids in 1960, RS 590 and Frontier 400B, at 101 quintals per hectare was only 8% above Combine Kafir-60.

Under irrigated conditions sorghum hybrids produced less than corn hybrids-101 against 120 quintals per hectare.

All of the hybrids tested, except NK 120, are too late for the French regions interested in sorghum production except in the Mediterranean areas. In these regions drought during the critical flowering period of corn is frequent and affects grain yield.

A certain number of early lines of the Station coming from the crosses S. 40 x Early Hegari, S. 40 x Bechna, E. Hegari x Caprock, and the earliest ordinary American varieties of our collection were crossed in 1960 with Combine Kafir-60 and Wheatland male steriles. Seed production was poor. The behavior of these hybrids will be examined in 1961 for the following: precocity, pollen restoration, productivity, and lodging.

A grain sorghum cultural experiment was conducted in 1960 under irrigated conditions with two hybrids, RS 590 and Wheatland x Redbine-60. Four rates of seeding were used: 4, 8, 12, and 16 plants per meter square. These rates were seeded in three row widths: 60, 80, and 100 centimeters.

The results are presented in tables 1 and 2. The highest yields were obtained with 8, 12, and 16 plants. The differences between row widths were not statistically significant (three replications).

Observations were made to determine the effectiveness of Simazine on weed control, especially in Chenopodium sp., Amaranthus sp., and Diplotaxis erucoides. Simazine was used in pre-emergence at the rates of 0, 1, 2, and 4 kilograms per hectare. Good control was obtained with the rates of 1 and 2 kg per ha without phytotoxicity for sorghum.

Table 1. Influence of plant spacing on yield (q/ha) of grain sorghum at 12% moisture.

Plant population (m2)	Row width (cm) 60	80	100	Yield (q/ha)
4	97.8	94.5	80.4	90.9
8	103.5	101.6	91.7	98.9
12	102.3	101.3	96.5	100.0
16	103.1	100.9	98.7	100.9
Av.	101.7	99.6	91.8	
L.S.D. (0.05)				4.8

Table 2. Effects of plant spacing on different characteristics of sorghum.

Plant population (m2)	Tillering	Head size (grams)	Stem Height (m)	Stem Coef. var. (%)	Grain moisture (Oct. 5)
4	2.7	82.9	1.06	11.7	30.8
8	1.6	75.9	1.13	12.0	28.4
12	1.4	65.5	1.12	9.3	27.7
16	1.1	57.0	1.17	8.6	26.6

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GEORGIA

A. R. Brown (Athens)

College Experiment Station hybrids 25A, 60A, and 64A continue to yield well in Georgia yield tests. Not enough hybrid seed was produced to enter them in the Regional Grain Sorghum Yield Trial, however. Several plant introductions were screened for possible male steriles in 1960. Four of these were found to be sterile producers when crossed with Combine Kafir-60 m.s. Twelve F5 selections of P.I. 221688 (yellow endosperm) x Redbine-60 looked very good in 1960 and will be used as parents in crosses involving male steriles. One F4 selection of Combine Sagrain x Martin was uniformly short and high yielding in 1960. It will be tested for yield and as possible parent material in 1961.

In an irrigation experiment reported in the 1960 Newsletter, supplemental water gave a significant increase in yield in 1960. Twenty-inch rows gave a significant increase in yield over the 40-inch rows. Foliage diseases were more prevalent on plants of irrigated plots than on non-irrigated plots. Percent lodging of plants was higher in 20-inch rows than in the 40-inch rows.

One year's results with brown-seeded grain sorghums (high tannin) as a feed for broilers indicate that broilers gain as well on brown seeded grain sorghum as they do on white or red grain sorghum. This is encouraging as dark seeded grain sorghums are a necessity in the Southeast for two reasons: (1) they are bird resistant, and (2) they are weather resistant.

Sorghum Experiments in Georgia*

H. B. Harris (Experiment)

Sorghum introductions

The F1 progenies from approximately 220 sorghum introductions crossed onto 72E (Combine Kafir-60 ms) were grown in paired rows with the parent introduction during 1960. This work was done in cooperation with Grover Sowell, Jr., Plant Pathologist, Southern Regional Plant Introduction Station, Experiment, Georgia.

Data were collected on plant height, disease susceptibility, and presence or absence of restorer genes. The detailed data which were collected are available in mimeographed form to those interested.

One hundred seventy-one of the plant introduction lines restored fertility in the F1 progeny, while 49 did not. Resistance to Gray Leaf Spot (caused by *Gleocercospora sorghi* D. Bain & Edg.) and anthracnose (caused by *Colletotrichum graminicolum* (Ces.) G. W. Wils.) generally appeared to be greater in the progeny than that of the introduction parent. This was expected since Combine Kafir-60 shows considerable resistance to these leaf diseases. Generally, resistance to Rough Spot (caused by *Ascochyta sorghina* Sacc.) was decreased in the F1 progeny since Combine Kafir-60 is rather susceptible to this disease.

Although specific notes concerning forage production of the F1 progeny were not collected, many of these hybrids appeared to be well adapted for silage production. Breeders who are interested in silage sorghums would do well to survey this source of germplasm.

Resistance to weathering

Since Georgia frequently experiences humid weather conditions during the period preceeding and during grain sorghum harvest, resistance to sprouting in the standing head and to the growth of saprophytic organisms on the seed are of utmost importance. These causes have been observed to account for a loss as great as 50 percent in grain yield in field plantings and in variety tests. When this occurs, the grain that is harvested is of low quality and not suited for commercially mixed feeds.

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*Paper No. 393, Journal Series of the Georgia Experiment Station, Experiment, Georgia.

The only observed genetic characteristic which has been consistently associated with resistance to weathering is brown seed color. From preliminary genetic studies, the presence in the dominant form of the B1 and B2 genes reported by Stephens (1) and the S gene reported by Vinal and Cron (2) appear to be necessary for tolerance to warm humid weather.

Further study is needed before valid conclusions can be drawn. This investigation will continue during 1961.

Brown-seeded sorghums have been considered undesirable on the basis of higher content of the tannin complex. This appears to be an invalid conclusion since the percent of the tannin complex is usually less than that observed in good quality alfalfa hay.

Studies on Forage Yield of 2nd and 3rd Generation Seed of F1 Hybrid Sudangrass and Sudangrass x Grain Sorghum

J. P. Craigmiles, J. P. Newton, (Experiment)
H. B. Harris and J. W. Dobson, Jr. (Blairsville)

In 1959 seed of F1, F2, and F3 seed of Suhi-1 hybrid grain sorghum (Rhodesian male-sterile x Tift) and Rhodesian male-sterile x Combine Kafir-60 were planted in a randomized block design at Experiment, Georgia. The purpose of this study was to determine how much reduction in forage yield was due to the loss of heterosis when second and third generation hybrid seed are planted.

One years results in table 1 shows that in sudangrass a 12-percent yield reduction was obtained when second generation seed were planted and a 30-percent reduction when third generation seed were used. In the grain sorghum x sudangrass hybrid, second generation seed caused a 5 percent reduction and third generation seed, 30-percent yield reduction when compared to the F1 hybrid.

Table 1. Effect of first, second, and third generation seed and forage production of sudangrass and sudangrass x grain sorghum, Experiment, Georgia, 1959.

	Dry weight per acre		
	Aug. 27	Oct. 27	total
		lb.	
Male-Sterile Rhodesian sudangrass	1158	5304	6462
Normal Rhodesian	953	5066	6019
Rhodesian x Tift, F1	2315	6426	8741
Rhodesian x Tift, F2	2111	5712	7823
Rhodesian x Tift, F3	2247	4488	6735
Rhodesian x Combine Kafir-60, F1	2860	8262	11122
Rhodesian x Combine Kafir-60, F2	2724	7854	10578
Rhodesian x Combine Kafir-60, F3	2588	5916	8504
LSD	213	408	927

1. Stephens, J. C. A second factor for subcoat in sorghum seed. Jour. Amer. Soc. of Agron. 38: 340-342. 1946
2. Vinal, H. N. and Cron, A. B. Improvement of sorghums by hybridization. Jour. Heredity. 12: 435-443. 1924.

"Suhi-1" Hybrid Sudangrass Released

J. P. Craigmiles (Experiment)

Suhi-1, an F1 hybrid sudangrass, developed by the Georgia Agricultural Experiment Station, was released in January 1961 for its high forage production, long growth period, and disease resistance.

Suhi-1 is the result of seed produced by controlled pollination between male-sterile Rhodesian sudangrass and Tift sudangrass. This hybrid is characteristically tall, vigorous, and late, producing more forage throughout the season and for a longer period of time than other varieties tested. It possesses wide leaves, semi-dry stems, and resistance to drought and disease. The dark seed, mostly reddish brown to black in color, tend to shatter at maturity, but remain sound in the soil and volunteer more readily than other sudangrass varieties.

Origin and development of Suhi-1

In 1946 seed of *Sorghum arundinaceum* (wild) Staph. were received in the U.S. from the Department of Agriculture of Southern Rhodesia, Africa. This African indogene is commonly referred to as Rhodesian sudangrass and is listed as PI 156549 by the Regional Plant Introduction Station, Experiment, Georgia.

In 1956 seeds of PI 156549 were crossed to male-sterile Combine Kafir-60. A cytoplasmic male-sterile Rhodesian sudangrass was developed by transferring the genetic factors of Rhodesian sudangrass to this sterile cytoplasm by a series of back crosses, using Rhodesian as the recurring male parent.

Suhi-1 sudangrass seeds are produced by allowing male-sterile Rhodesian to be pollinated with Tift sudangrass in an isolated field. Seed harvested from the male sterile rows are F1 hybrid seed.

Forage production

Forage yields have been obtained for four years at four locations in Georgia in uniform variety trials. The plots were clipped at intervals when the varieties reached a height of about 24 inches. Results from these tests (table 1) show Suhi-1 to produce 31 percent more forage than the average sudangrass tested and 22 percent more than Piper and Tift the highest yielding commercial varieties in the tests.

In Georgia and the Southeast late forage production is desirable. Suhi-1 continues to produce an abundance of forage until it is killed by frost. As shown in table 2, one-fourth of the forage produced by Suhi-1 was obtained at the last clipping.

Table 1. Four-year average forage yield of sudangrass grown at four locations in Georgia, 1957-1960.

Variety	Dry weight per acre by location				Av. all
	Experiment	Plains	Calhoun	Blairsville*	locations
	pounds				
Suhi-1	9328	7489	5846	18580	10312
Tift	7390	5088	3738	16000	8054
Rhodesian	6504	5463	4225	9522	6428
Piper	7474	5716	3614	15681	8021
Stoneville Syn.	7070	5538	3629	13072	7327
Av. 8 other sudangrasses	6281	5015	3666	13305	7067

*Three-year average, 1958-1960. Data from J. W. Dobson, Jr.

Table 2. Four-year average sudangrass forage yields by clipping dates, Experiment, Georgia, 1957-60.

Variety	Dry weight				
	June	July	August	October	Total
			pounds		
Suhi-1	2996	1890	2124	2318	9328
Tift	2299	1812	1967	1312	7390
Rhodesian	1892	1252	1384	1976	6504
Piper	2396	1855	1806	1417	7474
Stoneville syn.	2213	1624	1868	1365	7070
Av. 8 sudangrasses	2240	1055	1685	1301	6281

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ILLINOIS

H. H. Hadley (Urbana)

Studies of male sterility

Dr. S. P. Singh, an I.C.A. participant from India, conducted a study of anther tissue in male-fertile and in male-sterile Combine Kafir-60. Essentially, he found that both lines were the same except for the behavior of (1) the tapetal layer of cells and (2) the nuclei of microspores. In the male-sterile line the tapetal layer did not disintegrate and apparently failed to nourish the microspores. Furthermore, the microspores showed few if any divisions of their nuclei so that no generative or pollen tube nuclei were formed. More details and illustrations will appear later in Crop Science if the presently prepared manuscript is accepted for publication.

Another study was conducted with male-sterile material with the help of Dr. Singh. Counts of seed and sterile sessile florets were made on heads of ten plants in each of the following materials:

(1) male-sterile CK 60 x male-fertile CK 60
(2) male-sterile CK 60 x S. arundinaceum
(3) male-sterile CK 60 x S. virgatum
(4) (male sterile CK 60 x S. virgatum) x (male-fertile CK 60 x S. virgatum)

Percentage seed set in the hybrid male-sterile CK 60 x S. virgatum decreased on an average from main head to early tillers to later tillers. Average seed set on main heads of male-sterile CK 60 x S. virgatum was higher than that on ms CK 60 x S. arundinaceum (0.98 and 0.34 respectively). Although average seed set on main heads of the cross ms CK 60 x S. virgatum was almost the same as that on main heads of the cross (ms CK 60 x S. virgatum)x (male-fertile CK 60 x S. virgatum) variation was much higher in the latter. The variances were 2.99 and 10.11, respectively, giving a significant F value at the 10% level. This suggests segregation of weak restorer genes or modifiers in the "F2" hybrid.

Height studies in grain sorghum

The study of phenotypic behavior of nine height mutants (4 from 7078, 3 from B600 and 2 from B-602) has been completed by Jere Freeman. The nine mutants were assumed to be at the unstable dw3 locus. However, this should be checked by appropriate test crosses. Insofar as phenotypic expressions were concerned the mutants appeared to be the same except for one comparison. One mutant of B-600 was shorter than the other two. Out of numerous comparisons this was the only significant difference and thus could readily be assumed as caused by chance. Significant differences in height were observed among tall mutants in 7078, but the dwarf sibs also differed significantly. The indicated heterogeneity in 7078 renders useless the test for differences among the tall mutants. Thus, no good evidence was found that the tall mutants are different alleles in a multiple allelic series.

Mr. Phillip Watkins has collected all data from his experiment involving variation in plant height among the six possible crosses between Durra, Tall white sooner milo, Dwarf W.S.M. and Double dwarf W.S.M. He is now in the final stages of analyzing the data and details of the results and interpretations will be available later in the year in the form of his Ph.D. thesis.

Polyploidy

Numerous F2 plants from the cross 4n Dwarf Feterita x 4n R.F. (a selection obtained from J. G. Ross and C. J. Franzke) were observed in 1960. Many were surprisingly fertile. Selections were made for planting an F3 bulk as well as F3 progeny rows this year. An F1 between 4n male-fertile CK 60 and 4n Dwarf Feterita also appeared quite highly fertile last year so that many F2 plants will be available this year. Other F1's including species crosses 4n (ms CK 60 x *S. virgatum*) and 4n (ms CK 60 x *S. verticilliflorum*), were available and used in crosses to obtain maximum genetic diversity. Tetraploid hybrids involving the grassy forms, however, have smaller seed than grain sorghum forms.

Seedless, hybrid broomcorn

Early backcross generations indicate that recovery of broomcorn types from original crosses involving ms CK 60 will not be difficult. However, partial fertility apparently will be a problem. Consequently crosses were made between male fertile CK 60 x broomcorn in an attempt to obtain both A and B lines with genes for male fertility.

A program of transferring genes for seed shattering from *S. virgatum*, *S. verticilliflorum* and *S. arundinaceum* was begun. Special tester stocks for the 2 genes Sh1 and Sh2 are being developed.

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INDIANA

Sorghum Research in Indiana - 1960

R. C. Pickett, D. A. Miller, and W. L. Whitehead (Lafayette)

Moisture distribution at Lafayette was almost ideal so all plant development at all dates of planting was excellent. In southern Indiana there was widespread moisture deficiency and many farmer's trial plantings of close-row non-cultivated sorghum suffered lack of heading on drouthy hill sites. Populations were critical in many areas as was weed competition. On drouthier

sands cultivated rows are recommended for drouth insurance and sidedressing with nitrogen as needed. On better moisture sites several close-row plantings on a field basis yielded over 8,400 pounds (150 bu. per acre).

Weed control trials continue to be of critical evidence since a small amount of shading or weed competition with young sorghum plants have been shown to reduce yield greatly. Randox T and Atrazine both gave excellent weed control at normal rates with 7-inch row plantings yielding as high as 10,300 pounds. Up to 8 lb. of Atrazine reduced the stand to 65 percent, but the yield was not significantly reduced below the recommended lower rates.

A sorghum seedling cold survival test was worked on by a student, Ralph L. Obendorf. He found that seed subjected to temperatures of down to 36° for as long as 10 days germinated almost perfectly upon restoration of higher temperatures. Two days pre-treatment of germination for 2 days at 70° and then 36° for 10 days killed almost all seedlings. Only 5 days at 36° gave 40 to 85% reduction in seedlings which allowed preliminary readings for genetic differences in cold resistance among 19 sorghum hybrids and inbreds. Heights varied from 123 to 179 percent of the checks (no treatment) for these lines. Survival varied from 56 percent for Martin to 98 percent for CK 60 and 96 percent for RS 610.

Another student, Ed Cox, found that germination and growth of sorghum seed is decreased as temperature decreased. It was not severe at 50°F but was a major factor at 35° with a severe inhibition starting at 40° - 45°F.

Lodging trials for forage sorghums were tried with 3 dates of planting of hybrids in high population (180,000 plants per acre) in 7-inch rows. Four-foot borders were left between plots. Differential lodging occurred among planting dates and hybrids at the knee-high stage. This maximum population trial was an excellent test to make susceptible varieties lodge while the more resistant stood partially until frost.

Report on Experimental Studies

D. A. Miller

A study of various chemicals as gametocidal agents on sorghum

A gametocide study was undertaken during the summer of 1960 to determine the effect of 12 different chemicals on gamete fertility of sorghum, in hopes that one may find a selective male gametocide. Two varieties of sorghum, RS 610 and PAG 515, were treated with these chemicals at 3 stages of growth. The material was drilled and thinned to a rate of 15 lb. per acre in 8-inch rows. The stand was excellent and the leaf canopy complete for good weed control. A split-plot design was used with 4 replications. The chemicals were applied at 1/2, 1, and 2 lb. of active material per acre. The three stages of application were vegetative stage or 8 to 10 inches of height, 18 to 20 inches of height, and early boot stage (time of flag leaf appearance). The 12 chemicals were: aminotriazole, FW-450, dowpon, 2,4-D (check), 2,4-DB, DNBP, maleic hydrazide, seson (crag #1), 4-fluorophenoxy acetic acid, 2-chloro-4-fluorophenoxy acetic acid, 4-fluorophenoxy alpha propionic acid, and aBB trichloro isobutyric acid. The last four chemicals were supplied by Amchen Products, Inc. FW-450 was supplied by Rohm and Haas Chemical Co. Some of these chemicals were selected for use because of their chemical structure. A portable hand sprayer, with water and a detergent (Duz) as carriers, was used to apply these chemicals.

Data were taken on days to first toxic symptoms, days to flowering weed control, tillering, height, male and female gamete fertility, heads per plot, yield and threshing percentage.

Negative results were primarily found using these chemicals. Symptoms appeared within 1/2 day after application when 2 lb. per acre treatment was applied. All chemicals responded similarly. The flowering was delayed 2 days for every unit increase of chemical concentrations.

The main objective of this study was to determine the effect of these chemicals as a selective gametocide on sorghum. Pollen under microscopic examination, using iodine stain, determined male fertility and seed set on treated plants determined female fertility. Negative results on differential effect on male sterility were obtained in all cases. As shown in table 1, there was no significant selectivity between male or female sterility as induced by these chemicals. When male sterility was induced, female sterility was also induced.

Table 1. Effect of various chemicals on male and female sterility, plus toxicity ratings on sorghum.

	Mean Percent Sterility		
Chemical	Male	Female	Toxicity* 5 days after application
Aminotriazole	20	25	3
FW-450	26	30	1
Dowpon	15	35	1
2,4-D (check)	2	10	0
2,4-DB	0	20	1
DNBP	0	25	4
Maleic hydrazide	10	15	3
Sesone	5	12	1
4-fluorophenoxy acetic acid	75	70	5
2-chloro-4-fluorophenoxy acetic acid	45	40	6
4-fluorophenoxy alpha propionic acid	10	20	3
aβB trichloro isobutyric acid	20	25	2

* 0 = no apparent effect; 9 = severe plant damage.

Three experimental compounds, 4-fluorophenoxy acetic acid, 2-chloro-4-fluorophenoxy acetic acid, and 4-fluorophenoxy alpha propionic acid, reduced head size, height and head number, but still did not respond as a selective male gametocide. Tillering was induced by use of these three chemicals, mainly because the apical meristem was injured.

Seed harvested from each plot was grown to determine if any treatment had an injurious effect on germination or if any of the chemicals may act as a mutagenic agent. It was found that germination was reduced by a number of treatments. The chemicals which reduced germination were dowpon, 4-fluorophenoxy acetic acid, 2-chloro-4-fluorophenoxy acetic acid, and 4-fluorophenoxy alpha propionic acid at the 1/2, 1, and 2 lb. per acre applied at early boot stage. None of the chemicals induced any mutants.

In summary, none of the chemicals used in this study seemed to show any practical or commercial application as a selective gametocide.

Influence of date of planting on female sterility

A small trial was conducted in 1960 to determine the effect of date of planting on female sterility in various male-sterile lines of sorghum as measured by seed set. Eight male steriles were planted in 4 replications using split-plot design with date of planting as main plots. Fertile lines were planted in alternate plots to provide ample pollen at time of pollination. The mean effects are presented in table 2.

Table 2. Ratings of female sterility as affected by date of planting.

	Planting Dates		
	May 26	June 7	June 20
Male steriles	Female sterility[1]	Female sterility	Female sterility
Martin	1.5	2.5	6.5**
Redlan	2.0	0.0*	4.0**
Midland	2.0	6.5**	7.5**
CK 60	2.5	3.0	7.5**
RB 66	2.5	0.5*	6.5**
Reliance	3.5	3.5	4.0
Westland	7.0	8.0	9.0*
White Wheatland	7.5	7.0	9.0*
Mean	3.5	3.9	6.8**

1. 0 = no apparent female sterility; 9 = complete female sterility.
*Significant at P = 0.5 level.
**Significant at P = .01 level.

Few significant differences were found between the first two dates of planting. A number of significant differences were found comparing the last date of planting to the mean of the first two dates of planting as shown in table 2. As pointed out in the table, date of planting may have a great influence on female sterility in various male-sterile lines in Indiana. In general, it was found in 1960 that female sterility was increased as the date of planting was delayed.

Inheritance of partial fertility

Investigations are being continued to determine the inheritance of partial male fertility. Material was classified by microscopic examination of the pollen. Several hundred hand and hot-water emasculated crosses were made among the various lines of partial fertiles during the summer of 1960. These crosses are being grown in the greenhouse and winter nurseries at which time various backcrosses will be made. The progeny will be studied during the summer of 1961.

Cytoplasmic transfer and sorghum grafting

A number of embryo grafts have been made during the past year. This basic study was to help determine the cytoplasm-genetic interactions and the transfer of sterile cytoplasm. Sterile-cytoplasmic embryo grafts onto normal endosperm of genetic sterile and the reciprocal grafts have been made. The problem to

date was the failure to work under sterile conditions. Favorable sterile working conditions have been obtained recently and once under control, progeny of such grafts will be grown to determine cytoplasmic transfer.

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IOWA

Grain Sorghum Research and Testing

R. E. Atkins (Ames)

Performance tests for grain sorghum hybrids and varieties were conducted at five locations in Iowa during the 1960 season. Results for 1960 and the five-year period 1956-60 are available in Agronomy Leaflet No. 520.

Several selective herbicides were effective as pre-emergence sprays at Ames in 1960 in reducing weed populations without damage to sorghum stands and subsequent grain yields. Randox applied at a rate of 6 lb./A. was most effective, giving good weed control and a yield increase of 25% over the cultivated and hand weeded check plot. Several rates of Atrazine, Randox T and Simazine also were effective. Eptam, 2,4-D (Ester) and the 5 lb./A. rate of Simazine reduced grain yields to varying degrees. Eptam at the 3 lb./A. rate was particularly damaging causing a yield reduction of 24% in comparison with the cultivated-hand weeded check.

Grain yields for corn borer infested plots of two hybrids and two varieties of sorghum were reduced 5.5% at Ames in 1960 in comparison with the non-infested plots of these entries. For this same comparison 100-kernel weight was reduced 4.0%. Infestation was most severe in the Dwarf Yellow Sooner Milo plots. In a selected sample of severely infested heads in the Sooner Milo plots, grain yield was reduced 7.4% and 100-kernel weight 4.6% in comparison with a similar sample of non-infested heads.

Planting date studies in 1960 at Ames served to corroborate results obtained for similar tests in 1957-59. Moisture and temperature conditions throughout the full season in 1960 were adequate for uninterrupted growth and differentiation of the sorghum plant. Under these conditions average grain yields for each of six planting dates, from May 13 to June 17 did not differ appreciably, with a range of only 98 to 105 bushels per acre. However, moisture content of the grain at the first autumn freeze was progressively and markedly higher as planting date was delayed.

Seed dormancy studies, plus a refinement of previous freezing injury and viability studies were carried out by Mr. Earl Gritton as a part of his M.S. degree program. Results from these studies will be summarized and presented during the spring quarter. Comparisons of optimum size and shape of plot, relative efficiencies of several lattice designs and a comparison of hill and drill type plots are being evaluated by Mr. Koert Lessman as a part of his Ph.D. program.

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KANSAS

Certified Seed Production in Kansas - 1960

Wayne Fowler (Manhattan)

The acreage of all sorghum approved for certified seed production in Kansas in 1960 was 6465, slightly more than double the 1959 acreage. Approximate approved acreage, by type, was 1100 forage sorghum, 330 grain sorghum, 2340 open-pedigree hybrid sorghum, 2620 closed-pedigree hybrid sorghum, 75 seed stock, and 1 sudangrass.

The 1960 sorghum seed production was generally good and quality is fair to high. Germination seems unusually high overall; there is some seed discoloration. "Distress seed" is available at ridiculously low prices.

The 1960-61 winter test at Tampico, Mexico, indicated the 1960 Kansas seed crop to be capable of producing more satisfactory appearing fields than was the case in 1959.

KS651 and KS652 Grain Sorghum Hybrids

Agricultural Experiment Station (Manhattan)

Two grain sorghum hybrids, KS651 and KS652 (formerly experimental numbers 55HH69 and 55MH14, respectively), have recently been released by the Kansas Agricultural Experiment Station. These hybrids are single-cross hybrids produced by use of cytoplasmic male sterility. Male-sterile Combine Kafir-60 is the female parent of both hybrids. KS2, the pollinator parent of KS651, is a selection of Colby x Westland (originally designated 51H11). KS3, the pollinator parent of KS652, is a selection of Spur-Blackhull3 x Redbine-60 (originally designated 57M1201).

Seed of the new hybrids will not be available for large scale commercial plantings until 1962 or possibly 1963. They are expected to replace KS603 and KS602 as seed becomes available. Male parent inbred lines of these hybrids were planted in the Rio Grande Valley for increase this winter. If these plantings progress as expected, some parent stock will be available for planting seed fields this year.

KS651

The pedigree of KS651 (55HH69) is Combine Kafir-60 ms x KS2. It originated at the Fort Hays Branch Experiment Station, Hays, Kansas, and was first tested at that station in 1955.

In Kansas, KS651 is approximately the same maturity as RS650, KS602, and KS603. It is of good combine height, averaging two to three inches taller than RS650 and KS602 and two to three inches shorter than KS603. Head exsertion is good. The grain is light red in color and of good test weight, KS651 has stood very well in Kansas tests, having been equal to RS650 and KS602 and superior to RS610 and KS603. The yields of KS651 have been equal to RS650, slightly superior to KS603, and definitely superior to KS602. It is resistant to milo disease. In limited observations, KS651 has appeared to be as tolerant to chinch bugs as other Kansas recommended hybrids.

KS652

The pedigree of KS652 (55MH14) is Combine Kafir-60 ms x KS3. It originated at the Kansas Agricultural Experiment Station, Manhattan, Kansas, and was first tested at that station in 1956.

In Kansas, KS652 is approximately the same maturity as RS650, KS602, and KS603. It is of good combine height, averaging the same height as RS650 and KS602 and three or four inches shorter than KS603. Head exsertion is good. The grain is light red in color and of good test weight. KS652 has stood very well in Kansas tests, having been equal to RS650 and KS602 and superior to KS603 and RS610. The yields of KS652 have been equal to RS650, superior to KS-603 and definitely superior to KS602. It is resistant to milo disease. Although KS652 is not completely resistant to head smut, it has shown considerably less susceptibility than RS610 in Texas tests in 1959 and 1960. In limited observations, KS652 has appeared to be as tolerant to chinch bugs as other Kansas-recommended hybrids.

Crop Production and Physiology

F. C. Stickler and A. W. Pauli (Manhattan)

Row spacing-plant population tests in cooperation with various experiment field and branch station personnel were continued in 1960. In general, 20-inch rows showed little advantage over 40's. Row spacing and plant density interacted (10% level) in their effect on yield at only one location. These results have been mimeographed and are available for those interested.

Results from optimum plot size studies were summarized and have been published as Kansas Agr. Exp. Sta. Technical Bulletin 109.

Defoliation (leaf removal) experiments were concluded in the 1960 season, mainly because of the high cost required to conduct accurate tests. More work (which is needed) on leaf removal and/or simulated hail damage will be initiated only if more funds become available.

The phenology experiment, where maturity (days to 50% bloom) is being compared with hourly temperature at 8 locations, is being continued. The Kansas State University Statistical Laboratory has analyzed 1958 and 1959 results, and through multiple regression more than 90% of maturity variation can be explained by different temperature summations.

Studies on the effects of GA (gibberellic acid) are being continued. In 1960, a test was initiated to measure responses from high rates applied as a foliar spray. The value of single vs. split applications is being studied. Another test was started to determine possible differential varietal response from GA. Data collected in 1960 showed less response, in general, than in 1959. Varieties did not differ materially in their response.

Studies on comparative temperature responses of some selected kaoliangs and standard varieties were continued. Certain kaoliang entries are superior to Redlan insofar as speed of germination is concerned. Using dry matter increase as a measure of seedling growth, kaoliang entries were not superior to the standard checks, Norghum, Midland and Redlan. This test is in cooperation with A. J. Casady.

A study comparing performance of 4 grain sorghum genotypes grown alone and in various associations was continued in 1960. To date, the results indicate that performance when grown in pure stands will predict performance of a variety when grown in association with other varieties. Detailed yield component analyses are being made on these data.

Tests comparing different machines for establishing grain sorghum were continued. Press wheels were desirable, especially under more adverse conditions.

An M.S. thesis study was completed by Mr. Wilbur F. Evans. The problem dealt with temperature and moisture as factors affecting germination of grain sorghum. One interesting aspect was that gibberellic acid increased germination percentage relatively more under drought (using mannitol) conditions than without severe moisture tension. Seed source was found to be an important factor in the mannitol test and in germination in soil at different temperatures.

Progress Report on Several Studies at the Ft. Hays Branch Station

W. M. Ross (Hays)

Fertility restoration

The vagaries of environment, heterozygous and heterogeneous backgrounds, and modifying genes make the study of fertility restoration difficult. In order to circumvent factors other than environment, isogenic fertility restoration lines are being developed in Combine Kafir-60 (milo cytoplasm). Sources of fertility restoration include representatives of basic grain, forage, and grass sorghums. Backcross generations range from 1 to 5 from about 20 sources. Additional crosses, mostly with grass types, are in the F1.

Ultimately, segregation ratios will be studied in a uniform kafir background, and recombinations will be made to determine the relationship, if any, of fertility genes from different sources. If genes exist that are dominant for male sterility, they are likely to be lost, for backcrossing is accomplished only with the most fertile plants.

A milo source (SA 7078) of fertility restoration has been backcrossed sufficiently into four male steriles to make a preliminary study of segregation in backgrounds with moderate homozygosity. The results follow:

Restored A line	BC	No. fertile	No. sterile	P
Combine Kafir-60	4	57	68	.50-.20
do.	3	66	75	.50-.20
Redlan	3	55	70	.20-.10
Martin	4	66	66	1.00
Westland	5	77	53	.05-.02*
Total plants		321	332	.95-.50

The populations were grown under limited irrigation, and partially fertile heads were virtually absent. It is apparent that a single major gene is operating. Only Westland deviated significantly from an expected 1:1 ratio. Westland, however, is difficult to sterilize, and modifying genes are probably still present. It is interesting to note a skewed tendency toward sterility in the three kafir populations.

Cytoplasm substitutions

Cytoplasm substitutions or isoplasmic lines are under development in Combine Kafir-60. Excluding milo, backcross generations range from the F1 to the BC6 in about 50 cytoplasms. A large part of the crosses represent grass cytoplasm sources and will be backcrossed only to the extent of determining cytoplasmic male sterility.

No basic grain sorghum-hegari, feterita, shallu, durra, kaoliang or broomcorn - of the material sampled, has given cytoplasmic male sterility with the kafir chromosomes. Four to six backcrosses have been made.

The grass sorghums, on the other hand, have been rewarding. Sterility was obtained and intensified with each backcross in the following cytoplasms, the present state of development being indicated in parentheses:

Black Amber "sorgo" (BC5)
Greenleaf sudangrass (BC4)
S. arundinaceum, Genetic Collection No. 361 (BC3)
S. verticilliflorum, PI 208190 (BC2)

There are indications that sterility will persist using the cytoplasms of other strains of S. arundinaceum, S. virgatum, and S. niloticum var. Kavirondo. Whether or not the cytoplasms are the same as milo is to be determined. The isogenic fertility restorers, if different, can prove useful as testers to identify "new" cytoplasms, all in a kafir genetic background.

Hybrid mixtures

Theoretically, limited genetic variability might prove advantageous for sorghum hybrids grown in areas having erratic weather, such as under dryland conditions in the Great Plains. To test this hypothesis, five hybrids were grown singly and in 1:1 mixtures in 1959 and in 1960. The results follow:

Average yields of five hybrids alone and in mixtures, 1959-60.

Component	RS 610	RS 650	KS 603	KS 701	KS 602
			lb. per acre		
RS 610	--	3500	3340	3310	3140
RS 650	3500	--	3290	2960	3200
KS 602	3140	3200	3010	2990	--
KS 603	3340	3290	--	3000	3010
KS 701	3310	2960	3000	--	2990
Av. yd.-mixture	3320	3240	3160	3060	3080
Av. yd.-alone	3680	3260	3180	2980	2820

While RS 610 mixtures were generally high yielding they were no better than RS 610 alone. Low yielding hybrids generally contributed to low yielding mixtures. The actual and predicted (average of the two hybrids grown singly) yields of the ten mixtures were correlated significantly, r = +.80 and +.66 in 1959 and 1960, respectively.

Specific mixtures of two hybrids may not have enough variability. Additional information can be gained on this aspect by 1) studying mixtures of more than two hybrids and 2) comparing mixtures with three-way crosses where the same germ

plasm is involved. For example, (A1 x R) + (A2 x R) = (A1 x B2) x R in gene frequency where A, B, and R are sterile, maintainer and restorer lines, respectively.

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LEBANON

Grain Sorghum in Lebanon

W. W. Worzella (Beirut)

Twenty-four varieties and hybrids of grain sorghum were tested in replicated plots under irrigation during 1960 in Lebanon. The data are shown in table 1.

Table 1. Forage and grain yields and other characters of grain sorghum varieties and hybrids grown in the Bekaa in 1960, American University Farm.

Variety	Plant ht. (cm.)	Date of maturity	Forage yield tons/du. Green[1]	Dry	Grain yield kg./du.
Sorghum	122	31/8	2.0	0.48	478
Reliance	118	31/8	2.0	0.48	358
Dual	146	31/8	2.2	0.53	470
Martin	127	21/9	3.1	0.75	644
Midland	132	5/9	3.4	0.82	746
Caprock	117	21/9	2.8	0.68	694
Plainsman	106	21/9	2.7	0.64	642
Hegari	150	5/9	4.0	0.96	668
Early Hegari	152	5/9	3.3	0.79	684
Combine Kafir-60	117	21/9	3.1	0.79	611
Redbine-60	125	21/9	2.6	0.63	537
RS 501	131	31/8	3.2	0.76	494[2]
RS 590	126	21/9	2.7	0.74	676
RS 608	134	5/9	2.7	0.62	656
RS 610	127	5/9	2.9	0.68	786[3]
RS 630	130	21/9	2.5	0.61	836
RS 650	116	21/9	2.9	0.70	773
Texas 620	133	21/9	3.3	0.79	848
Texas 660	125	21/9	3.1	0.78	685
Neb. Exp. 71	122	21/9	2.6	0.63	745
KS 602	122	21/9	3.1	0.74	705
KS 603	137	21/9	3.7	0.90	802
KS 701	127	26/9	3.2	0.79	667
Local	232	21/9	3.7	0.88	539

1. The average moisture percentage of the green forage was 76.
2. 30 percent bird damage.
3. 10 percent bird damage.

It will be noted that the grain yield varied from 358 kg. to 848 kg. per dunum (1/4 of acre). The hybrids Texas 620, RS 610 and RS 630 gave the highest yield in 1960.

Eight varieties and hybrids of forage sorghums were tested in replicated plots under irrigation during 1960 in Lebanon. The data are reported in table 2.

Table 2. Yields of forage sorghum varieties and hybrids grown in the Bekaa in 1960, American University Farm.

	1st Cut			2nd Cut			Total	
		Forage yield T/du.			Forage yield T/du.		Forage yield T/du.	
Variety	Date	Wet[1]	Dry	Date	Wet[2]	Dry	Wet	Dry
Atlas	6/8	6.3	1.6	17/9	3.6	1.3	10.0	2.9
Rox	6/8	6.4	1.6	17/9	3.6	1.3	10.0	2.9
Axtell	3/8	5.6	1.4	17/9	5.1	1.8	10.6	3.2
Ellis	3/8	5.4	1.3	17/9	3.3	1.2	8.7	2.5
White Collier	23/8	8.7	2.2	17/9	1.1	0.4	9.8	2.6
RS 301F	3/8	6.8	1.7	17/9	5.2	1.8	11.9	3.5
Rancher	29/7	4.4	1.1	25/8	4.4	1.6	8.8	2.7
Local	1/8	4.7	1.2	20/8	2.4	0.9	7.1	2.1

1. Average moisture of green forage 75 percent.
2. Average moisture of green forage 65 percent.

It will be noted that some varieties produced only large quantities of forage at the first date of cutting (White Collier) while others produced high amounts of forage at both harvesting dates (Axtell and RS 301F). The dry weight yields of forage varied from 2.1 tons per dunum for the Local variety to 3.5 tons per dunum for the hybrid RS 301F.

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MINNESOTA

Herbicides for Grain Sorghum Plots

R. G. Robinson (St. Paul)

Annual weeds are a major problem in grain sorghum production in the humid northern corn belt. Cultivation alone will usually not give satisfactory control, and either herbicides or hand work is needed in experimental plots.

In 1957-60 trials, CDAA (Randox) at 4 lb/A in addition to cultivation gave excellent control of Setaria species and Echinochloa crusgalli and an average yield increase of 25% over cultivation alone. Occasionally CDAA caused injury but the sorghum recovered. If non-grass weeds are present in the rows, post-emergence application of 2,4-D is necessary. CDAA and 2,4-D are the only herbicides suggested for use on commercial sorghum fields in Minnesota.

However a one-application treatment for grass and non-grass annual weeds is desired. Furthermore a post-emergence herbicide for both grass and non-grass weeds would be of great value either as a first treatment or as a follow-up on an unsuccessful pre-emergence treatment. Herbicides possessing these advantages do not yet have residue clearance but could be used on experimental plots if the harvested seed or forage is not used for feed.

Two herbicides in this non-approved category are atrazine and propazine. Used at 2 lb/A either pre- or post-emergence, either product gave excellent grass and non-grass weed control and no sorghum injury. Probably propazine is the safer pre-emergence treatment, and atrazine the most effective post-emergence treatment. The major disadvantage of these two herbicides is that they may leave a residue in the soil that will affect the next year's crop.

Soil moisture and temperature affect the activity of these herbicides. Dry soil is unfavorable to pre-emergence treatments of atrazine or propazine. Cool weather is unfavorable to treatments of CDAA or its related herbicide CDAA-T. Mixture and combination treatments of these herbicides are promising, but more experimental work is needed.

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MISSISSIPPI

Norman C. Merwine (State College)

During what was considered to be a dry growing season in this area, RS 610 produced 10 tons of green weight per acre this year on a field scale. Feeding quality of this silage was better than corn which produced 11.5 tons on an adjacent part of the field. At the silage stage, yields of 40 bushels and 25 bushels of grain were obtained from RS 610 and corn, respectively. A second crop of seven tons of RS 610 silage was obtained from the regrowth of the stubble. Both corn and sorghum were harvested in the milk to dough stages. Stage of maturity appears to be very critical in harvesting sorghum silage. Preliminary observation suggests that grain sorghum should be harvested not later than three weeks past bloom. The relative value of grain and sugar as sources of carbohydrates for ensiling and silage nutritive value is being studied in cooperation with the Dairy Department.

Attempts to produce hybrid seed of trial hybrids on a field scale were again unsuccessful. In several different locations it was apparent that the previously observed yield superiority of a brown-seeded experimental hybrid may be due to a taste factor, repellent to birds, which is present in the milk and early dough stages of seed development. A chick feeding trial previously conducted showed no apparent rejection of the brown-seeded grain when the grain was fed in a ground mash.

Insecticide Damage to Sorgo*

O. H. Coleman, J. L. Dean, and D. M. Broadhead (Meridian)

Injury to sorgo leaves, apparently due to drift of an insecticide from adjacent cotton fields, was observed in the regional sorgo variety tests at Jackson, Tennessee, and at Crossville, Alabama, in 1957. Toxaphene had been used at Jackson and an organic phosphate at Crossville. A commercial planting of Honey sorgo surrounded by cotton was virtually defoliated when airplane dusting with methyl parathion was used to control cotton insects near Tchula, Mississippi, in 1958. Brix readings from this sorgo ranged from 3 to 5 degrees, whereas 15 to 18 degrees would have been considered normal. The farmer, who had planted the sorgo for sirup production, considered the crop a total loss and discarded it. Fortunately, he had also planted Wiley and Tracy (in a similar situation) and, although there was some damage to Tracy, he was able to produce sirup from both varieties. Wiley showed no evidence of injury.

In 1959 and 1960 chemical injury was observed on sorgo in the Regional variety tests where located adjacent to cotton. The problem is particularly acute in the Mississippi Delta, where airplane dusting to control cotton insects is a common practice.

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* Cooperative investigations of the Crops Research Division, ARS, USDA, and the Mississippi Agricultural Experiment Station.

The new entries in the regional sorgo variety test were very susceptible to methyl parathion dust at Stoneville, Mississippi, in 1959. It became apparent, therefore, that resistance to insecticides needed to be incorporated in the sorgo-breeding program. Since very strong resistance is available, spraying with methyl parathion was made an integral part of the breeding program at Meridian in 1960; the breeding plots were sprayed and evaluated for resistance to the insecticide when the plants were about 1 foot tall.

A genetic study was started in 1960 to determine the mode of inheritance of resistance to methyl parathion in sorgo. A highly resistant variety, Wiley, was used as one parent whereas a very susceptible variety, Honey, was the other parent. An F2 population involving crosses between these varieties was grown in 1960 and sprayed with methyl parathion when the plants were about 1 foot tall. The F2 distribution indicated that a relatively simple type of inheritance is involved. The F3 generation will be grown in 1961 to clarify the mode of inheritance of resistance to methyl parathion.

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NEBRASKA

Notes for the 1961 Sorghum Newsletter

O. J. Webster (Lincoln)

Sorghum production soared to a new record high of 86,102,000 bushels in 1960, a 40 percent increase from last year's big crop of 61,683,000 bushels. The yield at 50.5 bushels per acre was the highest on record. Acreage harvested totaled 1,705,000 acres, compared with 1,418,000 in 1959. Sorghum silage production increased from 627,000 tons in 1959 to 760,000 tons for 1960. Sorghum forage production was down 13 percent. The above information was reported by State-Federal Division of Agricultural Statistics.

Sorghum production in Nebraska exceeded that of wheat by nearly a million bushels. The production of sorghum grain in the United States for 1960 was 637,673,000 bushels, 585,253,000 bushels in 1959, and 261,008,000 bushels as an average for the 1949-58 period.

Seed of eight grain hybrids and one forage hybrid was produced under certification in Nebraska in 1960. The acreage of seed production was 2762 or 11 percent decrease from 1959.

Seed stocks of a combine type, juicy, sweet-stalked sterile line will be increased in 1961 and seed of two forage hybrids will be produced in experimental production fields. The performance of these hybrids is similar to that of RS 301F but the forage quality will be improved.

Duane Kantor conducted a study for his Master's thesis on the "Effect of Frost and Harvest Damage on Sorghum Seed." The information obtained from this study is of vital interest to seed producers and a summary was prepared and published in the Nebraska Experiment Station Quarterly, Summer Issue 1960, and was reprinted in the 1960 December Issue of Crops and Soils. The summary is as follows:

"Early fall frosts and mechanical harvesting may reduce the viability of sorghum seed. In a study at the University of Nebraska, freezing temperatures late in September and early October of 1957 and 1958 reduced viability of high moisture hybrid sorghum seed. Some seed fields were combined before frost when moisture of the grain was as high as 25%. The viability of the grain was very low even though it had been carefully dried.

"Two male-sterile lines, Martin and Combine Kafir-60, were used in this study. Seed from these lines was harvested at various moisture levels and subjected to freezing temperatures of 32, 29, 26° F. for periods of 4, 8, and 12 hours. The viability of the two varieties was not reduced when seed was subjected to 32° F. The viability of seed subjected to 29° was reduced but not more than 10% for any treatment. The viability of Martin seed frozen at 26° F. was not reduced when moisture content was less than 25%; on the other hand the critical moisture level of Combine Kafir-60 seed was 35%. Reductions in vigor were associated with those lots of seed of reduced viability.

"Heads of the two varieties were subjected to mechanical threshing at different cylinder speeds when the grain ranged in moisture content from 10 to 40%. Only visibly 'sound' seed was selected, treated with a fungicide and planted.

"Seedling emergence data indicate that seed having a moisture content of less than 20% was most ideal for threshing from the standpoint of maintaining seed vaibility. Threshing at the slowest cylinder speeds retained highest viability. The percentage of abnormal (stunted) seedlings increased progressively with severity of threshing.

"Even though only visibly 'sound' seed was selected from all machine-threshed samples and treated with a fungicide, the percentage emergence was much lower than in hand-threshed seed depending on severity of threshing. The results indicate that under some conditions internal damage takes place within seed as a result of the mechanical threshing process."

A second freezing study was conducted in 1960 using temperatures of 30 and 25 degrees and freezing periods of 5 and 10 hours.

Juan Munoz returned from Mexico, under a Rockefeller fellowship, and will do his research for his Ph.D. in sorghum cytogenetics.

Marco Wing, another student from Mexico under the Rockefeller program, is completing his Master's degree. His thesis includes a detailed study of the plant variability in F1 vs. F2 generations.

Ali Kamball, from the Sudan, is completing a comprehensive study on combining ability for his Ph.D. thesis. The results of this study should be helpful in suggesting an efficient procedure for testing new lines.

The fish and Wildlife Service, U. S. Department of Agriculture, provided three chemicals to be tested as possible bird repellents. These materials were sprayed on the heads as seed began to form. The results were negative as a means of repelling English sparrows.

Forage Production of Different Sudangrass Varieties Under Simulated Pasture Conditions and at Maturity

L. V. Peters and O. J. Webster (Lincoln)

A report of this study was given at the Annual Meeting of the American Society of Agronomy at Chicago, Illinois, in December, 1960. We are well aware that the varieties and hybrids of sudangrass grown in the United States exhibit a wide range of plant types, that is, from early maturing varieties developed in the northern states to late maturing varieties used in the South.

Because of the large forage yield at maturity of some of the late maturing varieties, as compared with the early maturing varieties, one might assume that these late varieties should be very productive when grown for pasture purposes. The Regional Sudangrass Variety Test at Lincoln, Nebraska, has been conducted to compare the forage yields of the available sudangrass varieties and experimental strains.

The responses of six varieties which were included in the test for the six-year period, 1954-1959, are reported here. Plantings were made with V-belt attachments mounted on a two-row Dempster planter with 40-inch spacing between rows. In this replicated test, plots were 2 rows 66 feet in length. A 25-foot section at the end of each plot was harvested frequently at pasture stages, in order to obtain yields which would simulate grazing. A 25-foot section of the remainder was harvested when the seed was mature. Five or six cuttings were taken from clipped plots annually, whereas mature harvests were made near the end of the growing season. Clipped plots were harvested when the average height was about 2 feet.

The relative percentage of clipped yield to mature yield for the variety Wheeler was 103; Piper, 81; Sweet 372, 71; Greenleaf 57; Georgia 337, 55; and Lahoma, 45 percent. Yield comparisons are shown in the table.

Comparison of clipped and mature yields of sudangrass.[1]

Variety	Clipped	Mature
	Tons/A.	Tons/A.
Wheeler	2.16	2.09
Piper	2.06	2.53
Greenleaf	1.81	3.20
Sweet 372	1.62	2.29
Georgia 337	1.59	2.89
Lahoma	1.38	3.06

[1]Based on oven-dry weight.

These tests show that mature sudangrass yields rank very nearly according to the maturity of the entries - the late ones yielding the highest and the earliest the lowest. This relationship does not hold true for the yields of the clipped plots, with Wheeler and Piper - both early maturing strains - giving the highest yields.

The conclusion from this study is that mature-forage yields are not correlated with clipped-forage yields for certain sudangrass strains. And since sudangrass is used primarily for pasture, its ability to recover rapidly after clipping or grazing should be used as the chief criterion in determining a strain's true yield potential.

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NEW MEXICO

Ronald W. Livers and C. H. Hsi (Clovis)

New Mexico enjoyed a record grain sorghum crop of 9 million bushels with a state average of 40 bushels per acre. About 65% of this was on deep-well irrigated land in the eastern part of the state. Grain sorghums comprise 70% of total sorghums with forage types and broomcorn contributing 15% each.

At the Plains Substation some phenomenal dryland yields were obtained in 1960 due to high seasonal rainfall. Varieties ranged generally from 50 to 75 bushels per acre, and hybrids were generally in the 75 to 100 bushel range.

An irrigation plant at the Plains Substation will add considerably to research possibilities. Performance trials and other research will be carried out both on dryland and with supplemental irrigation.

Anthracnose has become quite serious in several New Mexico broomcorn areas. In 1960 some 100 lines from the Illinois breeding program were obtained and grown on infested land near San Jon. Good screening for anthracnose resistance eliminated the majority of lines, and chances of obtaining some resistant lines with height and brush characteristics equal to Rennels #11 appear good.

Two phases of sorghum work which are being emphasized in New Mexico at the present time are resistance to charcoal rot, which appears promising; and search for better emergence and growth under cool temperature conditions. This latter study is just getting started. Some New Mexico experimental lines have demonstrated the best seedling vigor and emergence so far.

Summary of Variety Tests

G. F. Henry (University Park)

Demonstration test plots were begun in 1954 to study yield and adaptability of sorghum varieties for both grain and ensilage production. These plots were designed to give visual evidence of the difference in varieties grown in the many sorghum-producing areas of New Mexico. Grain sorghum is one of the four most important crops grown in the state. There were over 50 million pounds of sorghum produced in 1960, 18 percent above the 1959 production.

Hybrid grain sorghums have made a rapid advance in replacing the open-pollinated varieties in on-farm demonstrations. Ninety-four percent of the varieties tested in 1955 were open-pollinated types,while in 1960, 93 percent of sorghums tested were hybrids. A total of 55 varieties, open-pollinated and hybrid, have been tested as 508 individual entries in the sorghum growing counties.

In irrigated areas with altitudes up to 4500 feet the longer-maturing hybrids have been the best producers. The high yielders in 1960 were Amak R-12, Ranger, Texas 660, Dekalb F62 and F63 and Steckley R-111. The best producers in irrigated areas from 4500 to 5500 feet were Amak R-10, Texas 601, Steckley R-99, Dekalb E56. Varieties of about the same maturity as Early Hegari are required where the altitude is 5500 feet or above.

Best producing hybrids tested under dryland conditions in the northeastern area of the state were RS 608, Dekalb D-50, Dekalb E-56, Garst and Thomas 851, and RS 501.

The Agricultural Services Department, in cooperation with the Extension Service of New Mexico State University, has tested 22 varieties of sorghums for ensilage in an average of seven counties each year in seven years. Lodging is the principal problem in the growing of sorghum varieties and hybrids for ensilage. This lodging factor in sorghums can cause a harvesting expense that is not usually encountered in growing corn for ensilage. Many of the hybrids are not as high in sweetness of stalk as the open-pollinated varieties. The highest yielding sorghum hybrids in production in 1960 were Silo King, NK 3059, Beefbuilder, and Dekalb FS-22 and the leading open-pollinated varieties are Sart, Sugar Drip Crystal Drip and Sumac 1712.

Fertilizers for Forage Sorghum and Sudangrass in Southern New Mexico - 1960

B. C. Williams and C. E. Watson (University Park)

A fertilizer study was conducted on Gila silty clay loam at the New Mexico Agricultural Experiment Station at University Park using Sumac 1712 under irrigation. Fertilizers were applied on June 11, all phosphorus and potash and one-half of nitrogen, and the other one-half N on July 20. The rates were 0, 80, 160, and 240 pounds per acre of nitrogen and 0, 40, and 80 pounds per acre of P205 and K20 Urea, 0-20-0, and muriate of potash were the forms used.

The yields of forage sorghum were increased by applications of fertilizers. The greatest increment of increase was from nitrogen with both phosphorus and potassium showing small increments of increase. There was an increase in protein content with fertilizer application. Protein ranged from 3.75 percent to 8.06 percent with an average over all treatments of 5.06 percent. Dry matter percentage was affected by fertilizer treatment. Dry matter ranged from 18.71 percent to 36.49 percent with an average over all treatments of 26.78 percent.

From the standpoint of gross profits above fertilizer costs the 160-80-80 treatment was best showing a $67.80 per acre increase.

Table 1. Fertilizer effect upon silage yield and dry matter of Sumac 1712.

		Nitrogen-Lb/A.							
		0		80		160		240	
P205 lb./A	K20 lb/A.	Gr. Wt. T/A	D.M. %	Gr. Wt. T/A	D. M. %	Gr. Wt. T/A	D. M. %	Gr. Wt. T/A	D. M. %
	0	33.8	29.3	41.9	24.1	44.9	26.4	47.7	29.1
0	40	36.5	28.7	39.4	25.0	43.7	26.9	44.8	26.5
	80	42.0	28.1	41.0	25.0	45.0	22.3	44.4	25.0
	0	39.5	27.3	42.7	26.8	44.4	21.5	40.5	27.2
40	40	37.7	26.4	42.5	28.5	47.3	26.2	45.2	26.1
	80	39.9	25.7	44.8	31.6	41.4	25.1	46.4	30.0
	0	42.3	26.2	40.0	29.6	43.8	26.8	42.0	26.0
80	40	38.6	29.7	42.0	26.0	45.8	26.8	44.0	22.9
	80	44.7	29.4	39.5	30.0	48.4	28.1	47.5	32.0

Table 2. Yield of green matter per acre and percentage of dry matter for sudan varieties at different cutting dates.

Variety	1st cut Gr. Wt. T/A	1st cut D. M. %	2nd cut Gr. Wt. T/A	2nd cut D. M. %	3rd cut Gr. Wt. T/A	3rd cut D. M. %
Common	8.4	18.9	12.8	24.7*	7.5	16.9
Commercial Sweet	10.0	13.2	19.1	15.9	9.6	16.3
Piper	9.4	13.9	14.1	22.8	4.9	15.6
SA 372 S-1	10.5	12.4	18.4	20.7	10.2	16.8
Sorgrass	11.2	12.0	13.5	18.8	4.9	16.6
Wheeler	9.2	15.4	12.4	26.7*	6.5	18.7*
Grazer	14.8	11.6	19.3	15.9	6.0	15.2
Dekalb SX11	14.3	11.9	19.7	15.2	5.1	16.0
S. Alnum	12.4	11.9	14.0	21.6	3.5	17.3
Calif. #23	9.8	13.3	17.0	22.8*	8.3	18.2*
Greenleaf	9.1	12.7	18.7	16.5	7.0	18.0
Germain's Hybrid	14.9	11.6	21.0	14.6	6.5	15.5

* Partially headed at cutting time.

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OILSEEDS DEVELOPMENT CORPORATION

J. B. McOnie (Potgietersrus, Transvaal, S. Africa)

As we are still in the middle of our season here no finalized results are available at the present time.

Our sorghum research project has expanded enormously this year. The hybrids produced and sold locally are performing well and hold much promise for the future.

In our breeding program, stress is laid upon yield, drought resistance and malting quality with witchweed and midge resistance of secondary importance. No suitable hybrids with resistance to these two have yet been produced. An unusually damp summer has resulted in considerable damage as a result of infection by downy mildew. All hybrids and inbred varieties will be planted next season on infected ground in the hopes of finding resistance to these diseases.

Work is being done with 4-dwarf and yellow endosperm lines. It is hoped that by using a suitable yellow endosperm variety as an adjunct in the malting of native beer, the vitamin content of the beer will be increased. As practically all locally grown sorghum is used in the malting industry this might be of great assistance in helping to improve the diet of the native people, the thick beer being both food and drink to them.

On the genetical side the putting together of new hybrid combinations, production of new MS lines from local varieties and an inheritance study involving the diastatic ability of crosses between good and poor malting types are the main activities.

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OKLAHOMA

D. E. Weibel, J. B. Sieglinger, and F. F. Davies (Stillwater)

The Oklahoma Agricultural Experiment Station has released three sorghum hybrids. They were grown in the Uniform Observation Nursery in 1960 under the numbers OK 5901-Wheatland x Y-8, OK 5905-Redlan x Y-8, and OK 5906-Dwarf Redlan x Y-8. The male parent of these hybrids has white seed with yellow endosperm. In accordance with the recommendation of the Sorghum Research Committee, these sorghum hybrids should be designated as "hetero-yellow endosperm" hybrids. The Dwarf Redlan parent is somewhat similar to Redlan except that it is earlier, shorter, and has waxy endosperm.

The hybrids have been assigned the following numbers:

OK 612 Wheatland ms x OK RY8, OK 5901
OK 613 Dwarf Redlan ms x OK RY8, OK 5906
OK 632 Redlan ms x OK RY8, OK 5905

Preliminary classification of pearled grain from a population of F2 plants seems to substantiate the belief that there are two factors for yellow endosperm from Kaura. These factors may be approximately equal in effect, independent, and incompletely dominant. It appears that one of these factors for color is the same as is in Korgi.

White seed and partially white or white striped seed appeared in 1960 on otherwise brown seeded heads in derivatives from Kaura breeding lines. These do not seem to be the usual chimera, nor are they from the calico germ plasm.

The Effect of Spacing and Simulated Hail Damage on the Yield of Grain Sorghum

R. A. Peck (Goodwell) and F. F. Davies

Investigations to study the effect of simulated hail damage on the yield of grain sorghum were initiated at the Main Agricultural Experiment Station, Stillwater, and the Panhandle Agricultural Experiment Station, Goodwell, in 1954. These investigations have been financed in part by the Hail Insurance Adjustment and Research Association.

The farmer's first reaction to the destruction of his grain sorghum crop by a hail storm is to give up. His second reaction is to consider the possibilities of replanting or salvaging the hail damaged crop. At the time these investigations were initiated, little information was available as to the ability of the grain sorghum plant to recover from hail damage.

The specific objectives as set forth in these studies are: (1) to determine the various degrees and types of hail damage in regard to various stages of growth and to determine these effects upon yield; (2) to aid insurance companies in making fair adjustments of hail losses; (3) to aid the sorghum grower in determining what course of action to follow in regard to plowing the crop under, replanting, or leaving the hail damaged crop for harvest.

The results obtained from the simulated hail damage studies during the past six years have warranted continuation, and expansion in some areas of the experiment. The variety Martin sorghum is used in this test. Currently, the experiment is being conducted under irrigated conditions at the Panhandle Agricultural Experiment Station.

The main phases of study in these investigations are: (1) plant spacing; (2) shred, bruise, and break; (3) bruising intensity; (4) defoliation and cutting the plants off one inch above the ground; and (5) upper leaf removal.

Included in the following table is a sample of some of the yield data obtained on the simulated hail damage studies at Goodwell, Oklahoma.

A five-year summary of the mean yields and percent of check of Martin sorghum in the defoliation phase at four stages of growth under irrigated conditions, Goodwell, Oklahoma, 1954-1958.

Stages of Growth	Treatment: Check	1/4	1/2	3/4	Complete
1/2 Vegetative					
mean yield bu/A.	54.46	50.64	46.74	42.59	30.21
percent of check	108.12	100.54	92.79	84.55	59.98
Boot					
mean yield bu/A.	49.28	40.97	36.51	21.79	5.23
percent of check	97.84	81.34	72.48	43.26	10.38
Bloom					
mean yield bu/A.	47.79	45.20	34.42	18.29	2.42
percent of check	94.88	89.74	68.33	36.31	4.80
Milk to Dough					
mean yield bu/A.	49.96	42.42	42.68	32.67	11.62
percent of check	99.19	64.22	84.73	64.86	23.07

Mean of all checks; 50.37 bushels per acre.

Sorghum Insect Studies in Oklahoma

C. F. Henderson, H. G. Kinzer, J. H. Hatchett and E. A. Wood, Jr. (Stillwater)

The amount of insect damage to sorghum was much less than during the previous year. The greatest injury was caused by the sorghum webworm in late-planted fields, followed by the corn earworm, fall armyworm, corn flea beetle and chinch bug.

Regional corn earworm test conducted

In cooperation with the Kansas Agricultural Experiment Station, tests are being conducted to compare the effectiveness of DDT, Sevin and Phosdrin against the corn earworm in sorghum heads. In the first test with RS 610 sorghum the percentages of control were as follows: Seven, 81; DDT, 79 and Phosdrin, 59. The larvae were small, 75% being in the first three instars. Three other materials tested showed the following percentages of control: SD-4402, 80; toxaphene, 28; and Dibrom, 27. In the second test with KH-400C, a medium compact-headed type, the percentages of earworm control were as follows: Sevin, 79; Phosdrin, 77 and DDT, 71. The better control shown by Phosdrin in the second test was probably due to the lower temperatures at the time of treatment. The larvae in this test were small to medium with 53% being in the second and third instars. Counts were also taken in more mature heads where the larvae were much larger (only 6% in the second and third instars), and the degree of control compared with that in the mature heads. Controls for the above three insecticides 2 days after treatment were, respectively, for the immature heads 77, 79 and 63 and for the mature heads 63, 67 and 49 percent.

Effect of chemical control on sorghum webworm

In the second regional corn earworm test, sorghum webworms were also present. The following percentages of control were shown: Phosdrin, 99; Sevin, 89 and DDT, 63. In another test three additional insecticides were compared with the following percentages of control being observed: Dibrom, 93; phosphamidon, 87 and SD-4402, 39. Against the earworm larvae, which were mostly large, the percentages of control were as follows: Dibrom, 63; SD-4402, 55 and phosphamidon, 36.

Field applications of Sevin and parathion against corn earworm and sorghum webworm

Three hundred acres of a medium-open-headed type sorghum variety were sprayed commercially with 1.5 lb. actual Sevin (85% Sprayable) per acre by airplane at the rate of 4 gallons spray per acre. Counts made before and 3 days after treatment indicated a control of 96% of the webworms and 80% of the earworms. In another field, excellent control of the webworm was obtained with 1.5 lb. Sevin per acre, good control with parathion at 0.5 lb. per acre and poor control with parathion at .33 lb. Earworm control with parathion at both rates was poor.

Effect of corn earworm on yield of sorghum

A limited test was conducted to determine the effect of different corn earworm larval populations on the yield of grain sorghum. This was a pilot test to evaluate techniques for use in future yield experiments with this insect. Individual sorghum heads in the milk stage were covered with screen cages and infested with different numbers of second- and third-instar larvae. Observations made at intervals of 2-3 days indicated that the cages did not interfere with normal larval activity, and no cases of cannibalism were noticed. When most of the larvae were reaching maturity, the owner treated the field with a heavy dosage of parathion which killed most of the larvae that hadn't yet pupated. Although the test was ruined for an accurate determination of total larval damage, it was decided to count the pupae in each caged head and compare these populations with the respective yields. A linear regression indicated a reduction in yield of 3.9% per larva under the conditions of this test.

Chemical control against the corn flea beetle

Ten different chemicals were compared in field screening tests against the corn flea beetle infesting sorghum in the whorl stage. As in previous tests Dieldrin (82%) gave the best control, followed by SD-4402 (80%), toxaphene (76%), DDT (71%) and endrin (66%). More effective control would undoubtedly have occurred if large plots, rather than 2-row plots, had been treated. These results compare closely with those of previous tests.

Effectiveness of Di-Syston as a seed treatment against the corn flea beetle

Di-Syston was applied at three rates as a seed treatment in a greenhouse test against the cornflea beetle. The adult insects were caged on 20-day-old sorghum plants and mortality counts taken 6 and 9 days later. Good to excellent control was obtained after 9 days, but considerable plant damage occurred before control was achieved. The percentages of control at the indicated rates were as follows: .25 lb., 85; .5 lb., 91 and 1.0 lb.,100.

Fall armyworm control in corn and sorghum

An extremely heavy infestation of the fall armyworm occurred on a number of grain and forage crops throughout central Oklahoma. To compare the effectiveness of several chemicals against this pest, 12 plots of corn and sorghum which were 11 rows wide and 300 feet long were planted alternately at the Agronomy Farm, Stillwater. Because of the heavy infestation which threatened to kill the plants, treatment had to be applied 14 days after planting when the plants were quite small. The percentages of control for the emulsion sprays on fall armyworms infesting the corn were as follows 3 days after treatment: SD-4402, 100; endrin, 90; parathion, 87; DDT, 82; dieldrin, 81; Phosdrin, 77 and toxaphene, 75. Sevin (85% Sprayable) showed a control of 97% and was the second best material tested. Because of the small size of the whorls at the time of treatment, the 3 granular materials tested were not very satisfactory. The following percentages of control were obtained with these formulations: SD-4402, 78; endrin, 47 and Sevin, 27. However, with the heavy fall armyworm potential and rapid growth of the plants, the insecticides soon lost their effectiveness and infestation again built up at a rapid rate. Seven days after treatment the best materials showed controls of only about 70%, and in 14 days almost no control was evidenced. By this time, however, most of the corn plants had been killed in the checks and in plots treated with the less effective materials. On sorghum, the various materials gave about the same degree of control with approximately the same order of effectiveness. Although no plant mortality was observed in the sorghum plots, little, if any, fall armyworm control was noted after 14 days. It is of interest that on all counting dates there were only about one-third as many larvae in the sorghum as in the corn plants. Since the stands of corn and sorghum, respectively, were 3.12 and 3.24 plants per foot of row, it is apparent that relative abundance of host plants was not a factor in the heavier infestations of corn by this insect.

Billbug damage to sorghum

Approximately 50% of the sorghum plants in an experimental planting of the Agronomy Department were destroyed by the billbug species Sphenophorus recta Say. and S. destructor Chttn. Feeding takes place at the base of the stalk, usually at night or early morning, and the billbug, with head down, gouges slits in the outer layers of the stem so that it can feed on the tender inner leaf. Similar damage has been observed in experimental plots of sorghum in the Lake Blackwell area for the past two summers, but the insect causing the injury was detected for the first time this year.

Effectiveness of systemic insecticides as seed treatments against corn leaf aphid

In a greenhouse test Di-Syston, phorate and Bayer 30911 were applied as seed treatments at .25, .5 and 1.0 lb. actual toxicant per 100 lb. sorghum seed. Plants were initially infested 20 days after planting, and thereafter mortality counts were made and the plants reinfested with aphids every 10 days. When any particular treatment failed to show 80% control it was terminated. The length of time in days (parenthesis) that each chemical treatment exceeded this degree of control was as follows: Di-Syston .25 (30); .5 (40) and 1.0 (50); Phorate .25 (30); .5 (40) and 1.0 (40); Bayer 1.0 (20).

Effectiveness of Di-Syston applied as a seed treatment against chinch bug

In a greenhouse test Di-Syston was applied as a seed treatment at the rates of .25, .5 and 1.0 lb. actual toxicant per 100 lb. sorghum seed. Chinch bugs caged on 20-day-old sorghum plants had the following percentages of control 9 days later: .25 lb., 14; .5 lb. 34 and 1.0 lb., 51. It is apparent that seed treatment with Di-Syston was not effective against the chinch bug under the conditions of this test.

Effect of systemic insecticides on plant emergence as influenced by rates of treatment

Di-Syston, Phorate and Bayer 30911 were applied to RS 610 sorghum seed at rates of .25, .5 and 1.0 lb. actual toxicant per 100 lb. of seed in a greenhouse test. Phorate at the .5- and 1.0-lb. rates, and Di-Syston at the 1.0 lb. rate seriously affected plant emergence with the following percentages of reduction: Phorate .5 lb., 16; 1.0 lb., 24 and Di-Syston 1.0 lb., 22. Phorate had the greatest overall effect on plant emergence with an average reduction of 16%, followed by Di-Syston with 10% and Bayer 30911 with 2%.

Effect of systemic insecticides and rates of application on plant growth and development

Sorghum plants grown in ice cream cartons from seed treated with Di-Syston, Phorate and Bayer 30911 at rates of .25, .5 and 1.0 lb. actual toxicant per 100 lb. of seed were measured at 10-day intervals after planting. After 10 days young seedlings treated with phorate and Di-Syston at the .5- and 1.0-lb. rate showed mild to severe marginal leaf burn, and severe curling and malformation of the young leaves. However, all phytotoxic symptoms had disappeared 20-30 days after planting. Bayer 30911 had no phytotoxic effect at either rate, nor did any of the chemicals at the .25-lb. rate. Plant height measurements taken 10 days after planting showed that different rates of growth were associated with rates of treatment, but not with the chemical used. The average growth rate per plant in millimeters for each treatment during the first 10 days after planting were as follows: plants from untreated seed, 9; from seed treated at .25-lb. rate, 7; at .5-lb. rate, 7; and at 1.0-lb. rate, 6. The growth rates 20-30 days after planting were as follows: plants from untreated seed, 6; from seed treated at .25 lb. rate, 6; at . 5 lb. rate, 7; and 1.0-lb. rate 8. After 30 days the plants failed to show any appreciable differences in height among the treatment level and check. It will be noted that during the first 10-day period the rate of growth was negatively correlated with the rate of treatment, and after 20 days it was positively correlated with the rate of treatment. It is possible that the insecticide had a detrimental effect on the young seedlings and as the plants became older this effect was lost.

Effect of systemic insecticides and rates of application on plant survival as influenced by soil moisture

RS 610 sorghum seed treated with Di-Syston, Phorate and Bayer 30911 at .5 and 1.0 lb. actual toxicant per 100 lb. of seed were germinated in ice cream cartons and seedlings allowed to emerge in soil containing 50-60% moisture. After emergence, plants from each treatment were separated and exposed to (1) soil containing 50-60% moisture and (2) soil containing 20-30% moisture. Initial plant stand counts were made 7 days after planting and final counts were made 16 days after planting. Plant stand reduction was found to be insignificant regardless of treatment when plants were grown in soil containing 50-60% moisture; however, plant stand from chemically treated seed was moderately to severely reduced compared with untreated seed in soil containing 20-30% moisture. Little difference between rates of treatment could be shown, although pronounced differences among chemicals were obvious. The average percent reduction in plant stand for each chemical was as follows: Phorate, 28; Bayer 30911, 21; Di-Syston, 12; and untreated check, 4. It is apparent that a period of drought following plant emergence could be very detrimental to the stand of sorghum, depending upon the insecticide used.

Effect of soil moisture level on seed treatment with systemic insecticides

RS 610 sorghum seed treated with Di-Syston, Phorate and Bayer 30911 at rates of .25 and .5 lb. actual toxicant per 100 lb. of seed were planted in soils having moisture contents of 30-40, 60-70 and 90-100% of field capacity. The 90-100% moisture level and the .5-lb. rate had the greatest effect on plant emergence, and the 30-40% level and .25-lb. rate had the least effect. Little difference could be shown between chemicals, but in general plant emergence decreased at the higher rate of treatment and as soil moisture was increased. The highest percentage of plant emergence was at the 60-70% moisture range and the lowest at 90-100%.

Sorghum Cytogenetics

D. S. Borgaonkar and J. M. J. de Wet (Stillwater)

Cytological studies in Sorghum were started in this University by the late Dr. Robert P. Celarier and the work has been reported (Celarier, 1958, 1959a, 1959b). Part of his work is being continued since his death in December, 1959.

One collection each of the species S. dochna, S. intrans, and S. miliaceum was studied cytologically.

Name of Species	Location	n Number	Meiotic behavior
S. dochna	India	10	Regular
S. intrans	Australia	5	Regular
S. miliaceum	India	10	Irregular

The average frequency per cell at IM is 0.86I-9.57II in S. dochna, and it has a chiasma frequency of 0.62. Sorghum intrans forms regularly 5II at IM and has a chiasma frequency of 1.00.

One interspecific hybrid between S. sudanensis and S. roxburghii was found to possess 2n=20 chromosomes which forms 10II at I Metaphase, and it has a chiasma frequency of 0.97.

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Sorghums of Ethiopia

Edward G. Damon (Stillwater)*

Observations presented in this report are the result of a three-year study which began in July, 1959, and which will be concluded with the publication of a bulletin on the Ethiopian Sorghums in 1961.

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As a first step in the initiation of a sorghum improvement program in Ethiopia, a centralized collection of Ethiopian sorghums was established at the Jimma Agricultural Technical School during the period 1958-1960. The collection, which now consists of some 200 selections, contains approximately 43 varieties and approximately 80 distinct forms. Represented in the collection, however, are intergrades between most of the forms. For the most part, the sorghums are planted, not as selected varieties, but as varietal mixtures in Ethiopia.

That there is continual hybridization between varieties, there can be little doubt. This is evidenced by morphological studies of two of the major varieties from a given area of Ethiopia. For example, from the collection taken from Jimma, Ethiopia, a complete series of intergrades may be observed between the two varieties, Chabe Ady and Dapo. The grains of Chabe Ady are chalky white in color and appearance, have a thick starchy mesocarp and a vinaceous mucellar layer. The panicle is lax with the rachis fully extended, freely exposed and with the long panicle branches bare for the first 8-10 cm. The grains of Dapo are reddish brown with the mesocarp absent. The rachis of this variety is fully contracted; the panicle branches are long and pendant.

Among the intergrades between these two varieties, which are present in the Jimma collection, are types with the central rachis partially extended (one or two internodes extended but with the length of the primary axis exceeded by the length of the panicle branches) with grains which are dull, yellowish-white, bearing flecks of reddish pigmentation and having a rather thin, starchy mesocarp beneath which is the vinaceous mucellar layer.

The Amharic name applied to such intermediate types by the people around Jimma is Maschila, which is a general name applied to several sorghum types. It is interesting to note, however, that while Maschila is the most general Amharic name used by the Ethiopian people for sorghum, they do not use this name in reference to the distinct varietal types such as Chabe Ady, Dapo or any of the other distinct varieties which are grown in the given area and which are recognized by their qualities with reference to distinct uses, morphology, resistance to attacks by birds, etc.

Herbarium specimens and data for these studies have been collected from observation plots planted at the Jimma Agricultural Technical School in 1959. Most of the selections were planted in head rows except in those cases in which students at the Jimma Agricultural Technical School submitted seed samples of selections from their various provinces. Herbarium specimens and seed samples of the selections have been prepared in triplicate and deposited at the Imperial Ethiopian College of Agriculture and Mechanical Arts at Alemaya, the Agricultural Technical School at Jimma and at Oklahoma State University.

Vavilov (4) lists Ethiopia (Abyssinia) as one of the major centers of diversity of Sorghum. Snowden (3) lists 19 varieties and 42 distinct forms from material collected in Abyssinia and Eritrea. Included in the collection of sorghums which are now under study are several varieties not described by Snowden and also several varieties which are grown in Ethiopia in addition to being cultivated in the Sudan as indicated by Snowden.

Among the varieties which have not been previously described is the variety Bobe, from Walaga Province. The grains of this variety are very distinctive owing to their extremely large size, (5.5-6.5 mm long and wide) low density, predominantly starchy endosperm, thick starchy mesocarp, usually distinct lateral lines, vinaceous mucellar layer and the concave embryo-mark. The mature fruiting panicles of this variety frequently exceed 40 centimeters in length. The central rachis may be fully extended, fully contracted or partially extended. The peduncle is always erect. The panicle branches of the type in which the rachis

is contracted are long, pendant and bare for the first 13-17 cm. with the racemes crowded or clustered. The panicle branches of the type in which the rachis is extended are more rigid and upright.

There are two forms of this variety, Bobe Ady which has white grains (chalky white) and Bobe Dima which has red (reddish purple, salmon pink, or rufous) grains. Bobe presents a most striking appearance with its huge grains hanging in great clusters from its large panicles. It grows to a height of 2 to 3 meters and matures in about 6 months. It is grown in the lowlands by the Shankella around Nedjo. The grains are boiled whole for food or used in making porridge, talla (native beer), or Katkalla (native alcohol).

Sorghum production in Ethiopia

Of the cereals, sorghum was second only to teff in acreage planted in 1959. As estimated 560,000 acres were devoted to sorghum production (1) The estimated average yield is 1,240 lb. per acre (2) In the great sorghum growing area around Dire Dawa, the heads are stacked at harvest time in very compact, uniform head stacks near the tukuls (the grass-top houses) and the culms are shocked in the field. The stems are used in the building of tukuls and fences and for fuel. The sorghum is threshed by hand flailing, brushing away the glumes and winnowing.

Most of the Ethiopian sorghums have a rather long maturity (6-9 months). However, a variety called Shurre, which is grown around Mizan Teferi, matures in about 4 months and two crops a year are produced. Several of the Ethiopian sorghums have very brightly colored, very attractive grains. Of the varieties from Jimma, Ethiopia, the variety called Mao or Chabe Ady shows the greatest resistance to attacks by birds. Mao has chalky white grains with a dark vinaceous nucellar layer. The panicles are lax with the central rachis extended and freely exposed.

Most of the sorghums in this collection exhibit characters by which, according to Snowden's classification, they would be classed as varieties of Sorghum subglabrescens Schweinf. et Aschers. A few of them would be classed as S. durra Stapf. by Snowden's classification.

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PENNSYLVANIA

Forage Sorghum and Sudangrass in 1960

J. B. Washko (University Park)

Sudangrass and sudangrass-sorghum hybrids test

Yield data and chemical composition were determined for various varieties and hybrids. Of the sudangrass-sorghum hybrids the two commercial hybrids, Volkman and DeKalb SX-11, were most productive of forage at two locations. The Texas sudan-sorghum hybrids which looked so promising in 1959 did not perform on a par with the two commercial hybrids mentioned.

Forage sorghum varietal test

Yield data and chemical composition of the various sorghums were compared with corn. The 3 highest yielding forage sorghums at two locations were Asgrow Silo King, FS 301F hybrid, and NK-3065. These forage sorghums outyielded hybrid

corn at University Park but not at Landisville. This can probably be attributed to the drought that prevailed at University Park during August but did not extend to Landisville.

Forage sorghum fertilizer experiment

As found by 2-years' data such summer annuals as corn, sorghum, pearl millet and sudangrass; when seeded in drill rows 7 inches apart; are not sensitive to P and K levels. Nor did any of the species show a response to either the 0-1-1 or 0-1-2 ratio of these plant nutrients. The tremendous differences between years is due to the effect on dry matter production of a wet year (1959) and a droughty year (1960) at University Park, Pa. In neither year did different levels of P and K have an effect on forage yields of these species when removed at the silage stage.

The summer annuals respond to nitrogen, provided moisture is available. In 1959, when rainfall was adequate, dry matter yields were increased as nitrogen rates increased from 50 to 200 pounds per acre. During 1960, a droughty year at University Park, Pa., none of the species responded to the various nitrogen levels used. In general, as the rate of N increased from 50 to 100 pounds per acre, greater yields of dry matter were obtained than when the N rate was increased from 100 to 200 pounds per acre. It does not appear that the 200-lb. nitrogen application could be justified economically on the basis of increased dry matter production.

A differential response of species to nitrogen fertilization was obtained. Corn gave the greatest response followed in turn by forage sorghum, sudangrass and pearl millet. Both the sudangrass and pearl millet showed little or no response in yield to the second 100-lb. increment of applied nitrogen.

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PIONEER HI-BRED CORN CO.

The Inheritance of Restoration of Fertility in Cytoplasmic Male-sterile Sorghum - A Preliminary Report

Harold J. Kidd (Plainview, Texas)

The studies of last year were continued, with plantings at Plainview, Texas; York, Nebraska; and Johnston, Iowa. Caprock was used as one source of restoration in a repetitive study and Day was added as a source of restorer genes. The sterile strains were the same as last year: 26-1 A (a selection from our breeding program), Martin A, and Combine Kafir-60 A (a selection somewhat more sterile than other Combine Kafir-60 sub-strains we have seen). Since bulked seed was used for each strain, some heterogeneity is likely. For this reason, we are presenting only a summary in the Newsletter.

Environmental effects on the expression of cytoplasmic male sterility in sorghum have been relatively regular in our observations. Of all climatological factors, temperature correlates best with sterility, although an effect of humidity could be masked due to the correlation of temperature with humidity in the areas where observations are being made, especially in the extreme high temperature ranges. Drought stress seems to accentuate high temperature effects. In general, the higher the temperature, the more likely is male fertility to be found in plants carrying Milo cytoplasm, at least within the range of environments where we have observed male steriles and restored plants. In other areas, such as Chillicothe, Texas (conversations with J. C. Stephens), the temperature frequently exceeds the limit for optimum development of sorghum pollen, so that

all pollen fertility is reduced. With extremely low temperatures (daily highs of 50° F. or less), as encountered occasionally for several successive days in Florida during the winter, pollen fertility will be so low even in the most fertile lines or hybrids that seed set is very poor whether or not the pollen source is controlled. Anyone familiar with cytoplasmic male sterility in maize will note that the typical reaction to temperature effects is reversed as compared to that plant.

The anther classification used is the same as last year, and its description follows:

Class 1 - sterile. Anthers exceedingly shriveled, but without any of the dark brown flecking found in the intermediate classes. Color is uniform white or pale yellow when fresh or the normal color for dry anthers in the same strain when a day or more old, or slightly darker appearing due to the shrivelling.

Class 2 - nearly sterile. Appearance very like class 1, except that some dark brown flecks appear, even on fresh anthers. Color of the undarkened parts is white to pale yellow while fresh. On close observation, it may be noted that the anthers are very slightly broader than class 1, especially at the base, and consequently are rather like a very pointed arrowhead.

Class 3 - intermediate. Here flecking is most severe of all classes, frequently ranging up to about 15% of the anther surface. Anthers are somewhat broader than class 2, and the arrow shape is more pronounced. Pores may be seen with the aid of a glass, but not in all anthers. Under temperatures of 95° F. observable amounts of pollen are shed.

Class 4 - nearly fertile. Anthers generally plump and significant quantities of pollen are produced. Some brown flecking may be observed in fresh anthers, but it is considerably less severe than in class 3 except under rare conditions. Frequently this flecking is the only observable indicator of difference from class 5 except for very small differences in plumpness and pollen shed. Pores may usually be seen with unassisted normal vision.

Class 5 - fertile. Anthers generally plump and bright yellow. A cloud of pollen is usually produced. Essentially no flecking is found but occasional anthers will be obviously deformed and entirely dark brown. Pores are larger than in class 4 anthers.

In general, difficulty is encountered principally in spearating class 1 from 2, and class 4 from 5. Thus far, the brown flecking has been a very reliable index. Naturally, rarely will a fertile panicle have no deformed anthers, so that care need be exercised in separation of class 4 from 5.

Correlation of anther class with seed set when bagged to induce self-pollination may be seen in table 1; each datum represents a tiller panicle bagged on a plant on which a panicle has been classified.

Table 1. Frequency distribution of selfed seed set and anther fertility classes, Plainview, Texas, 1960.

Anther class	Estimated seed set 0	26 seeds	up to 25%	25-75%	75-95%	95%	Total
1	72	5	2	0	1	0	80
2	22	10	5	1	1	1	40
3	9	4	3	0	1	0	17
4	0	1	4	0	5	9	19
5	3	2	4	3	32	163	207
Total	106	22	18	4	40	173	363

From a test for independence on the above data $X2 = 344.678$, $Df = 25$, $P = .01\%$ (tabulated $X2 = 44.314$, $P = .01$). From even a casual observation of this table, it may be seen that correlation between anther classification and seed set is very good. The correlation would likely be improved by space-planting in some manner to reduce errors in judgment regarding which shoots are tillers, since there was some error here.

In 1960, fertility as scored with approximately equal at Plainview and York, at which locations it was greater than Johnston. In some instances, single-gene ratios are obtained in both F2 and backcross populations, and ratios range up to those expected for four genes. One will expect divergence under different environments in a character as greatly effected by environment as is fertility. It is probably significant that in each case of indicated complexity of inheritance, the ratios indicate the action of a single major gene coupled with one or more modifiers with additive action. In some cases, perfect fits to usual ratios were not obtained. Usually fluctuations in environment, especially temperature, during flowering were noted on the same populations.

As with maize, the ratios vary with the environment, but in sorghum the simpler ratios are obtained at fairly high ranges of temperatures, or backcross ratios of 9:7 have even been noted at temperatures above 95° F., indicating that when three modifying genes are dominant, complete pollen fertility is attained even without the dominant major gene.

An index to the range of variation which environment may cause in the anther classification has been obtained from observations of the same inbred lines under different environments. Among the sterile strains (Martin A and Combine Kafir-60 A) the most sterile selections will be but rarely more fertile then class 2 unless temperatures are very high, if pure-line breeding has been carefully done. At moderate temperatures, selfed seed set is almost always zero. Westland, a variety less readily sterilizable, usually will be classed 3 in the most carefully selected strains, and these same lines will frequently be scored class 4 at higher temperatures; selfed seed set ranges from a scattered few to an estimated 80%. Among restorers, Tx 74 in hybrids (as in Texas 611) is rarely scored better than class 4, but usually sets seed well when bagged for self-pollination. SA7078 in hybrids (as in RS608 and RS610) is nearly always scored class 5, even though it is not under as close selection as in the other cases. Occasionally bagged panicles of RS610 will set less than 95% seed under a bag.

Seed set varies considerably more than anther class. Since pollen fertility needs to be below a certain threshold before it limits seed set, one would expect similar variations to occur.

Studies are continuing, using only pure-line selections for all strains. The sterile strains are the same, and the sources of restorer genes are Spur Feterita, Dwarf Early Milo, and white durra (Sorghum cernuum Host) selection of unknown origin which is intermediate in its fertility reaction to milo cytoplasm.

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RHODESIA & NYASALAND FEDERATION

Sorghum Work in Southern Rhodesia

Matopos Research Station serves the drier areas of Southern Rhodesia where sorghum has many advantages over corn for grain and is also the highest yieldingg silage crop on certain soils.

The program at Matopos consists of finding varieties and hybrids suited to the local environment. The main feature of the climate is an extremely variable rainfall, from 10 to 55 inches, concentrated in a very short and variable season from 65 to 135 days. The start of the growing season depends on rainfall since carryover soil moisture reserves are low (after 7-9 months with little or no rain) and the end of the season is defined by soil moisture becoming inadequate. Temperatures reach their maximum about 6 weeks before planting and steadily decline throughout the growing season. Although available soil moisture is considered the factor defining the end of the season, temperatures are low for sorghums toward the end of the season.

Very significant negative correlations have been established between variety yield and their maturity rating and for much of the areas served varieties or hybrids that flower in 50 - 60 days are most successful.

Yields have been increased very significantly by close spacings and high seed rates. After four years of field trials the optimum is considered to be 30 lb. of seed per acre drilled in rows 18 in. apart.

Studies of moisture consumption, leaf areas, ground cover, size and number of heads and quality of grain in widely differing spacings are being conducted to find reasons for the success of these high plant populations.

Northern Rhodesia

E. Mudenda (Chilanga)

Breeding

Segregates which appeared to combine resistance to bird damage with the desired malting qualities were selected in the F3 population of three crosses made in 1957. There were again some indications that resistance to bird damage was relative to the size of the bird population and to the availability of alternative food supplies.

Selection

The sorghum hybrids USK 23, USK 30, USK 32 and SA 36 were tested in a comparative yield trial. The hybrids outyielded all the selected standard varieties inspite of the fact that the panicles of USK 23 showed sterility to some extent and seed set was poor. The grain of this hybrid has the highest crude protein content at 13.44%.

A study of the diastatic powers (activities of enzyme diastase) of sorghum malts of selected varieties is being made in order to select the types required by the brewing industry.

The sucrose content of some introduced and local varieties has been and is being assessed. The results obtained so far show that a local variety Chimbowe has the highest sucrose content at 11.38%.

The ecological conditions differ considerably over the territory's 290,000 square miles. The varieties selected at the Central Research Station, Mount Makulu, have therefore to be tested further in the various regions. A comparison of yields in various regions show that early maturing dwarf varieties with a height of 3 to 5 feet are more suited to areas of low rainfall (20 to 35 inches) while the late maturing tall varieties with a height above 5 feet are more suited to areas of high rainfall (above 35 inches).

Agronomy

Results from factorial experiments carried out here on red clay soil show that sorghum, like maize, gives a positive response to applications of nitrogen but shows no response to applications of either potash or phosphates. There is an indication that a spacing of 36 inches x 12 inches is optimum for tall late maturing varieties and a spacing of 36 inches x 6 inches is slightly below optimum for dwarf varieties. In this experiment nitrogen was applied at the rate of 42 pounds per acre and superphosphates (19% P_2O_5) were applied at the rate of 200 pounds per acre.

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ROCKEFELLER FOUNDATION

Collections of Indigenous Sorghums of India

K. O. Rachie and L. R. House (New Delhi)

A systematic and comprehensive collection of indigenous varieties of sorghums, which occupy more than 40 million acres or about 11% of India's cultivated land, has not previously been made in this country except for localized sampling within certain regions for particular stations or projects. Therefore, the Rockefeller Foundation, in collaboration with the Indian government through the Indian Council of Agricultural Research is now making an intensive survey and collection of sorghums in India. Simultaneously, the millets and maize are being collected.

Sorghums are widely grown throughout India with the exception of higher elevations and heavy rainfall regions. In north India sorghum is grown in the summer principally for fodder. In central and south India two crops of sorghums are planted each year (though not on the same land) and in these regions it is grown as a dual purpose crop.

Sorghum is most intensively grown in the states of Maharashtra, Andhra Pradesh, Mysore, Madras, and Madhya Pradesh; and collecting was carried out in these regions first to help serve the immediate needs of the breeding program.

Procedure

Each collecting team is equipped for living and traveling in remote areas. A Jeep Station-wagon is used in pulling a trailer which is loaded with essential equipment. The general procedure has been to work through local officials in each state and area. The field areas for collection are therefore subdivided on political rather than ecological regions. Indian states are divided into Divisions, Districts, Tehsils and Taluks and Villages. A district is roughly equivalent to a US county and forms the most important geographical unit from the standpoint of collecting.

Agricultural Officers are contacted in each district. The officer in charge or a designated representative usually accompanies the Field Collector throughout his tour of the district which includes visits to representative villages and perhaps consultation with taluk officials.

Insofar as possible, collections are taken from the standing crop. The period of field operations is therefore limited to six months starting about October 1. Kharif (summer) crops are harvested starting in October and November and continuing into January. By early February the rabi (fall-sown) crop becomes mature enough to harvest. Both sorghums and millets are collected simultaneously even though it may be necessary to request samples of the threshed and stored grain. It would be impractical during this operation to attempt visiting each area at the time of maturation of every crop.

About 20 heads of sorghum, 15-20 ears of maize or 25-40 heads of millets are collected for each respective sample. Occasionally more than one sample may be collected from the same field if distinctly different varieties are grown together as a mixture. It is customary in some areas to grow two or more different purposes and to serve as a kind of crop insurance under hazardous conditions.

Individual collections are identified by an assigned collection number together with information on the location where it was picked up, a brief description of its development and productivity under the prevailing conditions, its growing period, special characteristics or uses of the variety collected and cultural practices used in producing the crop. Information on crop growing conditions, problems or pests, and cultural practices, utilization and methods of preparation for food is taken in greater detail on a district or area basis.

Crop samples received by the metriculation center (The Indian Agricultural Research Institute, New Delhi) are dried and examined regarding their invariant characters. It has been found impractical to take quantitative measurements on collected samples owing to the great variation in conditions under which crops are grown in India. Rather, a limited number of observations are made on certain invariant characters such as grain color, quality and relative size; compactness and shape of the head, presence of awns; and the shape, texture and size of glumes. Heads are then threshed and the seed is treated and stored under conditions of controlled temperature and humidity.

Field evaluation under uniform conditions will be carried out at several locations representing different ecological zones when the field collecting has been completed. This will afford an opportunity for studying plant development under the range of conditions prevailing in different regions during different seasons of the year. During evaluation the collected materials will be classified, identified and described; similar collections will be bulked and the important characteristics of each composite will be recorded. Simultaneously, superior types will be identified for breeding purposes. Particular areas or regions yielding superior strains may be more intensively collected following the identification and evaluations of the collections.

Present accomplishments

The first period of field collecting was started on October 5, 1959, and continued until March 31, 1960. Operations were begun in Rajasthan and continued in Western Madhya Pradesh and the winter sorghum growing regions of Maharashtra (then part of Bombay state). Collecting was resumed on October 3, 1960, in Southern Punjab and proceeded with Gujarat and Madras. Operations are continuing in Kerala and Andhra Pradesh and it is expected that Mysore, Eastern Madhya Pradesh and Orissa will be completed by the end of the 1960-61 collection season on or about April 15, 1961. It is anticipated that the work for the rest of India will be completed by April 1962.

A total of 1116 crop collections were made from October 1, 1959, to March 31, 1960. An additional 1040 samples were collected by the two field units operating during the present season through January 10, 1961. Crops sampled in the states where collections were made are as follows:

Crop	Total number of samples collected	Percent of total
Sorghum	1192	55
Pearl millet	386	18
Maize	219	11
Small millets	359	16
Total	2156	

On the basis of the above collections it is estimated that approximately 4600 samples will be collected in India, of which about 2500 will be sorghums.

Statistics on field operations

The gross area collected and miles traveled during this period of 292 unit-collecting-days are as follows:

Total miles traveled for the collection project (through January 10, 1961)	35,839
Miles traveled per day while collecting	102
Miles traveled per collection	13.7
Number of districts collected by April 15, 1961*	190
Number of districts remaining to be collected in India after April 15, 1961	136
Days required to collect each district	2.65

*Average size of an Indian district is 3895 square miles.

Collecting the 136 districts remaining after April 15, 1961, will require an estimated 340 unit-collecting-days or 170 days for two field collecting units. This approximates one season of work for two units. Altogether, field collecting in India will require about 865 unit-collecting-days.

Sorghum Research in Mexico

Elmer C. Johnson (Mexico City)

The sorghum introductions from Africa under the names Magune, Wyundo and Mabere, produced full seed-fill at 7,300 ft. elevation at Chapingo, Mexico, and partial seed-filles at 8,600 ft. at Toluca, Mexico, in 1960. Early Hegari planted as a check failed to produce seed at either location. This is the first time that any variety so far tested has produced seed at the Toluca Station.

Since great areas of the low rainfall parts of Mexico lie above 6,000 ft. elevation, these sorghums will be used extensively in breeding work for these areas.

If anyone knows of additional material that might lend itself to production under low temperatures, we would be most happy to hear about it.

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SOUTH AFRICA

P. M. le Roux and W. J. van der Walt (Pretoria, Transvaal)

A breeding program with grain sorghums has just been started at this Institute (University of Pretoria). Inbreds, hybrids and varieties have been received from the F.A.O. in Rome, India, Uganda and local areas.

A selection that appears to be resistant to midge (Contarinia sorghi) has been obtained from one of the local varieties. This short term selection is being tested out and improved further. Another variety segregates for yellow seedlings. Plants have been selected that breed true for this characteristic which is apparently determined by a single recessive gene.

Downy mildew caused by Sclerospora sorghi is causing heavy losses in both sorghums and corn in the Northern Transvaal. A search for resistant varieties will start during the coming season. Any information on this disease and resistant varieties would be welcomed.

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SOUTH CAROLINA

Alfred Manwiller (Florence)

A very limited grain sorghum breeding and testing program has been in progress at Florence, S. C., for several years. Farmer interest is spasmodic, and the total potential for the state will never be large, but there are areas in the Sandhills and Piedmont where corn cannot usually be profitably grown and sorghum can.

Birds are a problem, even to adequate testing, while humid fall weather and damage by stored grain insects demand a very open head of the shallu type. Breeding is chiefly directed at standability, open head type and earliness.

Vernon M. Kirk (Florence)

Two major insect pests of grain sorghum heads may now be controlled with a single application of insecticide without making either the grain or the foliage unfit for use as feed. When Sevin is applied as spray or dust at 2 lb. per acre when the heads are at half-bloom, the corn earworm and the fall armyworm infestations are reduced to insignificance for the remainder of the season under South Carolina's conditions. Sorghum webworms are also reduced, but insufficient data are available on this species. The nature of the insecticide residues is such that this material does not concentrate in milk, meat or poultry products.

Both the corn earworm and the fall armyworm prefer the tight-headed sorghums. When the really open-headed varieties are grown, infestations of these insects are so light that controls are seldom needed.

SUDAN

A Further Note on Sorghum in the Clay Plains of the Central Rainlands of the Sudan

W. M. Tahir (Wad El Nail)

Tahir and Idris (1) have described in some detail main sorghum growing areas in the clay plains of the Central Rainlands of the Sudan, methods of production, sorghum species and objectives of research.

Pedigree line selection in local varieties started in 1952 has given a range of strains suited to various agricultural conditions. These strains are fully mechanized and include: A) Short term (up to 95 days), dwarf, drought resistant-T.U.B.7, T.U.B.11, T.U.B.22, T.F.M.7; BO Medium term (95-105 days), dwarf to medium height, fairly resistant to drought, somewhat susceptible to lodging-T.E.F.4; T.E.F.6; Tozi Bahana 1, 2 and 3.; C) Medium to long term (over 105 days), dwarf, resistant to lodging, fairly resistant to drought-TD6; and D) Medium to long term (over 105 days), medium to medium tall (over 135 cms), somewhat susceptible to drought-T.M.11, T.M.18, Tozi Wad Aker.

Amount and distribution of rainfall determine the suitability of these strains to different areas of the rainlands. However, all of them yield better than introduced varieties and are superior to varieties which have been in production in the rainlands up to now. Therefore, for the first time, farmers in the mechanized sorghum production areas have locally bred sorghum strains suitable to their farming conditions.

Although selection is proceeding in other local varieties, more emphasis has now to be placed on grain quality for local consumption where elasticity of dough and color and taste of final product (Kisra) are the determining factors. The Caudatum group of varieties, from which combinable strains have been selected, have poor grain quality either due to testa and seed coat color or bitter taste of Kisra. All varieties of the Feterita group are similarly unsuitable except Gassabi which has white seed coat, colorless testa and gives satisfactory Kisra. Unfortunately Gassabi gives very low grain yield, tillers profusely, and is tall. Selection in this variety has not been so far successful. However, in a series of crosses with some combinable strains (Bonita x Hegari, T.U.B.7 and Tozi Wad Aker), it has given potentially useful lines which are dwarf, with good extrusion of head from flag leaf, early to medium maturity, non-tillering, resistant to lodging and drough, and have white seed coat and colorless testa.

Another variety belonging to the Durra group, locally called Zirazira, has a colorless testa, creamy seed coat, and intermediate Kisra quality. It is, however, late-maturing, tall, poor yielding, susceptible to smut, and has very poor extrusion and small grain size. It has been crossed with some combinable strains (Bonita x Hegari and Tozi Wad Aker) to improve its agronomic characters.

In a third series of hybrids for grain quality an introduced combinable variety Queensland Kalo, which has red seed coat but colorless testa, has been crossed to Tozi Wad Aker, which has dirty white seed coat and dark brown testa. Recombinations have given lines with colorless testa, white seed coat, and combinability superior to Tozi Wad Aker and similar to Queensland Kalo.

Three-Gassabi, (Bonita x Hegari, T.U.B.7.), and Queensland Kalo-were crossed with Tozi Wad Aker; are in F5 in 1961 and will fill the quality gap in mechanized sorghum production in a few years.

It was reported last year that American experimental station sorghum hybrids, which had been tested in 1958 and 1959, were not superior to local bred strains in grain yield and were highly susceptible to lodging (22% to 60%) compared with T.U.B.7 (5%) except RS 501 (8%) and RS 630 (9%). Although RS 630 at 2256 r.p.f.* was comparable in yield to T.U.B.7 at 2288 r.p.f. in its first year of testing in 1959, it has a colorless testa and white seed coat, and gives better quality Kisra. Due to this reason RS 630 is being tested under different climatic conditions in the rainlands to investigate its usefulness during the interim period before local crosses for quality grain are available.

Replacement of old varieties in the area by new combinable strains has the danger of eliminating the genetic diversity in sorghum in its primary center of origin. It is, therefore, imperative that for future progress genetic variability should be preserved. All variable sorghum types in the Sudan are being collected and are to be maintained at a central place. Morphological and agronomic characters of 350 types so far collected have been fully recorded and are being annually kept under observation.

Reference

1) Sorghum in the clay plains of the central rainlands of the Sudan. W. M. Tahir and Hussein Idris. Sorghum Newsletter 4: 66-71. 1960.

Acknowledgement

I am grateful to the Chief, Agricultural Research Division, for his approval to communicate this paper.

*r.p.f. = approximate lb./acre.

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TEXAS

Acreage of Certified Sorghum Hybrids for Seed Production in Texas 1956 to 1960

J. R. Quinby (Chillicothe)

Eight grain sorghum hybrids were put into production by the State Experiment Stations and the United States Department of Agriculture in 1956, and seven of them were grown for seed on 9 thousand acres in Texas under the certification program administered by the State Department of Agriculture. More than 23 thousand acres were grown in 1957, 13 thousand in 1958, 20 thousand in 1959 and 22 thousand in 1960. Five additional hybrids have gone into production since 1956.

Farmers grew substantial acreages of hybrid sorghum for the first time in 1957. The acreages planted to the different hybrids for seed production in 1958 probably reflect seed-grower's estimates of farmer's preferences after the growing of the 1957 crop. In 1959, the acreages probably reflect the purchases made by farmers in 1958. The 1960 seed-production acreage should be a reasonably good reflection of farmer's choices among the hybrids.

RS 610 appears to be the most acceptable hybrid because its seed-production acreage has been increasing. Its record in yield trials is one of the best. RS 608 was put into production in 1958 and its seed-production acreage increased in 1959 and again in 1960. Texas 601 and Texas 660 have just about held their own and in 1960, together, they occupied 11 percent of the acreage planted for

RS 501, Texas 611, Texas 620 and RS 650 are out, or practically out, of production. Of all the certified hybrids, only RS 630 is white seeded. Its future is uncertain in spite of its high yielding ability. RS 609, RS 661 and RS 681 have been named more recently and none of these have as yet been grown on a seed-production acreage in excess of 1 percent of the total. Whether they will be accepted by farmers is not yet apparent.

Acreage of certified sorghum hybrids 1956 to 1960, inclusive.

Hybrid	Percentage of the total acreage in the years* 1956	1957	1958	1959	1960
RS 501			1-	1-	
RS 590	10	9	1	2	1-
Texas 601	3	4	5	2	4
RS 608			8	14	19
RS 609					1-
RS 610	47	47	59	72	67
Texas 611	6	4	2		
Texas 620	25	23	7	4	1
RS 630		2		1-	1-
RS 650	6	5	10	1-	1-
Texas 660	3	6	8	5	7
RS 661				1-	1-
RS 681					1-
Total	**9592**	**23067**	**13105**	**20722**	**22668**

***Less than 1% indicated by 1-.**

Effect of Cropping System - Treatment Combinations on Grain Yield and Incidence of Head Smut in Grain Sorghum at Temple Texas in 1960

J. W. Collier and A. L. Cox (College Station)

A study involving grain sorghum in different cropping system-treatment combinations was conducted at the Blackland Experiment Station near Temple, Texas, in 1959 and 1960. Corn was used in 7 previous years. Cropping systems were grain sorghum following grain sorghum and grain sorghum following sweetclover. Four treatments included nitrogen fertilization and supplemental irrigation in 4 combinations. Hybrid RS 610 was used. Head smut incidence was rather high in 1960, and counts were made in all plots. The experimental design was a split plot with 4 replications. Grain yields and percentages of head smut (plants) are shown in table 1.

Table 1. Grain yields per acre and head smut percentages from cropping system-treatment combinations at Temple, Texas, in 1960.

Treatment combination		Grain yield lb./acre	Percent head smut (plants)
Grain sorghum following sweetclover			
No N	No irrigation	3820	6.7
No N	Irrigation	4090	11.1
90 lb. N	No irrigation	3820	6.7
90 lb. N	Irrigation	4150	12.6
Continuous grain sorghum (2 years, 7 years corn)			
No N	No irrigation	520	10.0
No N	Irrigation	900	15.4
90 lb. N	No irrigation	2800	18.0
90 lb. N	Irrigation	3050	25.0

Within the continuous grain sorghum system, the main effects of both nitrogen fertilization and supplemental irrigation are significant in increasing head smut incidence. These data emphasize the desirability of avoiding growing grain sorghum after grain sorghum in this area and also the necessity of developing smut resistant hybrids.

Head smut data from several similar experiments will be collected in 1961.

Measuring the Rate and Extent of Root Growth of Sorghum with Aid of Radio-active Tracers

J. G. King, T. E. Haddox, and J. W. McClure (Lubbock)

A preliminary report was submitted to the Sorghum Newsletter in 1959 showing the rate and extent of root growth for Texas 620 and its parents Tx 3197B and Tx 07R. This work was expanded in 1960 to include four milos differing by one gene for height and a forage sorghum, Sumac 6550.

Measurements were made by placing small amounts of radiophosphorus at given distances, laterally and vertically, from hills of sorghum grown under field conditions. The presence of radiophosphorus in the aerial parts of the plant, as detected by a Geigermuller counter, was considered evidences of root growth into the zone containing the tracer material.

From emergence through the fifth week after planting very little variation in root growth was measured. At the close of this period all sorghums were shown to have extended their roots approximately 45 inches vertically and 22 inches laterally.

By the time of exsertion all varieties extended their roots over fifty inches vertically and 45 inches laterally into the soil.

Considerable variation was measured in the amount of root growth between exsertion and flowering. During this period Tx 3197B extended its roots approximately two inches uniformly into the soil. Tx 07R sorghum showed an extension of approximately five inches, Sumac 6550 sorghum approximately eight inches and Texas 620 over twelve inches during this period.

Between flowering and maturity of the grain very little root growth was measured in either of the parent of Texas 620 or in the forage sorghum. The hybrid showed a marked increase in root activity during this period.

Considerable interest has developed in the possible use of 4-dwarf lines in sorghum hybrids. With this continuing reducing of plant height, the second part of the study was initiated to determine if reducing height affected root growth. Four isogenic milo lines were used in this study. The 1-dwarf is the tallest and the 4-dwarf is the shortest.

Little difference in root growth between types was noted until the seventh week after planting. Up to the seventh week all had a vertical movement of 40 inches and lateral growth of 20 inches. From the seventh to eighth week the 1- and 2-dwarf plants showed no lateral expansion of root growth while the 3-and 4-dwarf plants had lateral and vertical root growth to 40 inches. Lateral growth was greater for the 3-dwarf than the 4-dwarf plants.

This is primarily data, but, there appears to be very little difference in the root growth between a 3-or 4-dwarf plant. Why the wide difference in laterial root development between the 1- and 2-dwarf and the 3-and 4-dwarf plants is not known. Verification of field studies are underway in the greenhouse using a 2- and 4-dwarf plant.

Mineral Accumulation and Distribution in Grain Sorghum

H. C. Lane and H. J. Walker (Lubbock)

The accumulation and distribution of nitrogen, phosphorus, and potassium was followed in grain sorghum throughout the growth cycle. Samples were collected from plots receiving different fertilizer treatments so that the effect of the supply of nutrients on growth, accumulation, and distribution could be illustrated.

Redistribution of N, P and K in the plant during ontogeny was measured, however, sampling was not adequate to show clearly its magnitude.

In general, the mineral nutrition of sorghum is similar to that of corn and other plants. It does seem that sorghums continue to accumulate N P K during the final stages of development perhaps to a greater extent than corn.

The duration of growth, that is, the time to develop from one developmental state to the next was shortened by better nutrition. Growth was accelerated early and late, an greater leaf area developed on the faster growing plants, and the leaves tended to remain in functional condition for a longer time.

Although sorghums appear to absorb nutrients throughout the growth cycle, it is very likely that growth responses to fertilizers during the early stages of development are most important to yield.

Influence of Plant Population and Fertilizer Levels on Leaf Area Index of Grain Sorghum

H. C. Lane

The leaf area index on RS 610 grain sorghum grown on plots receiving application of different fertilizers was measured weekly throughout the growth cycle. The results shown on table 1 were obtained.

Table 1. Leaf area index on grain sorghum grown with different fertilizer treatments.*

Growth stage	Fertilizer 0-0-0	80-80-0	80-80-80
Early boot	3.17	2.93	4.35
Bloom	2.41	3.15	4.50
Mature grain	1.97	2.79	3.55

The results were fairly variable and cannot be considered evidence of real effects at this time. Even after considerable effort to obtain uniform stands, there was considerable variation in stands that made the measurements of the relationship between leaf area index and some of the fertilizer treatments rather useless. In otherwords, plant population seems to have a great influence on leaf area index.

TEXAS RESEARCH FOUNDATION

The Physical and Chemical Composition of Sudangrass as Related to Palatability

E. O. Gangstad (Renner, Texas)

Commercial and experimental seed stocks of 30 varieties of sudangrass and related sorghums were studied for palatability preference of the grazing animal (1958-60) by planting in single-row plots 20 ft. long and 3 ft. apart with 5 replications, and grazing at early flowering to about 50% utilization. Forage samples were taken immediately before grazing for physical and chemical analyses.

Preliminary statistical analyses gave the following highly significant correlation coefficients for percent grazed forage and:

leaves	.3687
moisture	.4488
protein	.3883
nitrogen-free extract	.3588
fiber	-.3302
ether extract	.3950
total ash	.2720
calcium	.2535
phosphorus	.2916
potassium	.4118

General correlation coefficients of percent grazed forage to plant weight, plant height, or total yield were not found significant.

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*Leaf area index = area of leaves (sq. in.) to proportionate land area (sq. in.).

UGANDA

Sorghum Work in East Africa

H. Dogett (Serere, Soroti)

The tetraploid work reported last year has been continued. Further lots of the autotetraploid cross (4N x5) made in 1955 have been grown, and the data analyzed. The F7 lines gave mean percentage seed sets ranging from 59% to 79%, grouped as F6 families the means ranged from 53% to 76%, and as F5 families from 67% to 75%.

The analysis has been done so far on the angular transformation, but this does not give sufficient correction, and a log x + c transformation is now being calculated. On the angular transformation, variances and co-variances were as follows:

Generation (grown simultaneously)	Variance
23B parent	56.12
38 parent	72.78
4N x 5, F1	37.43
F2	66.54
F3	81.12
Mean of F3 rows	65.41

Generation (grown simultaneously)	
F4	26.29
F5	28.99
F6	23.52
F7	23.68

Generation (grown different seasons)	Covariance
F2/F3	30.51
F3/F4	- 0.39
F4/F5	- 0.76
F5/F6	3.62
F6/F7	0.55

Selection for high seed set was done in the F3 and continued to F7. The high variance of the parents is not unexpected; they were heterogyzons and had not been selected for seed set. The F1 was from a cross of one female head and several pollen parents; its variance could, therefore, be lower. The high F2 and F3 variances, followed by the sharp drop shown by the covariances on the application of selection, indicates that seed set is behaving as a genetically controlled character.

Crosses with S. almum

The autotetraploid grain sorghum 23B crossed with S. almum gave the following segregation. Again, the parents had not been inbred and selected for seed set.

Percentage set	Number of Plants 23B	Almum	F1	F2
0 - 11	6			2
12 - 23	14			7
24 - 35	6			9
36 - 47	1			13
48 - 59	--	1		30
60 - 71	--	2	4	66
72 - 83	--	15	9	90
84 - 95	--	43	6	50
96 and over	--	2	-	--

This frequency table has, of course, been condensed, but the suggestion is again that of a genetically controlled character, with high seed set at least partially dominant.

New tetraploids

One hundred twenty-six varieties were treated with colchicine, and 79 yielded autotetraploids, a further 12 giving some doubtful tetraploid plants. Set counts on the tetraploids where there were several plants suggested that there may be differences in seed set. Four examples are given:

Variety	Seed set %	Range	No. plants counted
L28	80	78.5 - 80.3	3
Sakwa	72	68.2 - 77.3	3
Martin	55	49.1 - 62.6	3
N1	38	20.0 - 61.9	3

Summary

It looks at the moment as though tetraploid seed set is genetically controlled, the genes being variously distributed at the diploid level. *S. almum* seems to have genes for high seed set, which may be presumed to have come from its halepense parent.

Future

We hope to have the fertility problem in autotetraploid sorghum solved fairly soon. We shall begin to test this season the combining ability of the autotetraploid lines available with the object of obtaining tetraploid hybrids in which the hybrid vigor will be lost more slowly than in diploids, thus reducing the frequency with which seed would have to be renewed. This would be very valuable in undeveloped countries.

Collection

Through the generosity of the Rockefeller Foundation we plan to maintain a large collection of predominantly African sorghum types here. We hope that a Science Graduate of Makerere College (University of East Africa) will go to the U.S.A. for further training in 1962 and return to take charge of the collection in 1964.

Grain Studies

D. Jowett (Serere, Soroti)

Investigations have been carried out on the anatomy of the seed coat of 60 sorghum varieties, largely of African origin. A considerable amount of variation has been found in the structure and pigmentation of the seed coat. In particular the hypodermis may be absent or up to 3 cell layers across; the epidermal and hypodermal cell walls may be heavily thickened or only slightly so; the cuticle may be thin or thick; the mesocarp, which may consist of starch packed parenchyma cells or collapsed cells without starch, may be from 15 - 125 u across; the inner integument may be present or absent in the mature grain, and where present usually contains brown pigment to a greater or lesser extent. This pigment usually extends to the layer of tube cells immediately above the integument. The epidermis/hypodermis may also be pigmented, this pigmentation varies in color and intensity and is independent of that in the integument. These results agree with those of Ayyangar and Krishnaswami (Proc. Ind. Acad. Sci., B, XIV 114-138).

We are interested in elucidating the exact nature of the factor in colored grains conferring bird resistance (see Doggett's notes in Newsletter No. 3). Currently it appears likely that the important region is the persistent inner integument, particularly where this is densely pigmented. Thus Dobbs, the variety quoted by Doggett as bird resistant at Kongwa (Tanganyika), shows only slight pigment in the epidermis-hypodermis, but possesses a densely pigmented inner integument.

The factors in sorghum promoting bird resistance and the concurrent unpalatability are undoubtedly concentrated in the outer layers of the grain.. We are, therefore, interested in anatomic structures promoting ease of decortication, using a small electrically driven barley pearler. We hope in this way to produce a palatable flour from bitter, bird resistant grains. So far only grains with a good outer layer of corneous endosperm have given satisfactory results, and these are usually white. In addition we have noticed that where a densely pigmented integument is present, the pigment is particularly strong in the thickened inner cell walls of this layer. It has proved difficult to clean this off completely. We still hope to adjust the machine to overcome these problems.

The 60 sorghum varieties were scored 1 - 7 for the amount of corneous endosperm present, 7 signifying solid corneous. The number of grains in a 4-gram sample was counted as an estimate of seed size, and then the samples were soaked in water for 24 hours at 25° C. Water uptakes were estimated as a percentage of the original weight of seed and varied from 30-60%. Partial regression analysis showed that the rate of uptake of water was independent of cuticle and dermal characters, but the coefficients on corneous score ($b1 = -.0937$) and grains/4 gm. ($b2 = .0754$) were significant at the 0.1% level, and that on mesocarp thickness was significant at the 5% level, i.e., large seeds with a corneous endosperm and thin mesocarp take up least water.

It was thought that slow uptake of water may promote slow germination, which is sometimes an advantage under African conditions where the seed may be planted in a dry seed-bed. In such situations it is desirable that the seed should not germinate in the earliest rains which are likely to be spasmodic. However, repeated tests have failed to show any relationship between the rates of water uptake and speed of germination.

Experiments where sorghum grains have been soaked for varying periods and then air-dried have added little information. Soaking the seed followed by drying does not appear to affect ultimate germination unless the embryo begins to grow. This it does not do until after 20 hours at 25° C. However, non-corneous

endosperm types have usually burst the seed coat by this time, and are very fragile, whereas the corneous grains are whole and can be handled without breaking up. This may explain farmers' preferences for corneous types when dry planting. The non-corneous types possibly cannot survive in the soil if drying conditions follow early showers.

Breeding for Bird Resistance

D. Jowett

Doggett's large glume and long awn lines have been evaluated. The most promising large glume types are segregating from the cross 56 x 53. A line in F5 shows a mean glume length of 11.67 $\pm$ 0.61 mm. This compares with a value of 10.35 $\pm$ 0.39 mm. for Feki Mustakke, which was the long-glume parent in this cross. Clearly transgressive segregation has occurred, and the grain cover is visibly much improved in the 56 x 53 lines.

The best long awn lines were in BC2BLKO (backcross to BC27 of the cross BC27 x BELKO). The mean awn length of all lines in F7 was 17.9 $\pm$ 0.51. Crosses this year have been designed to combine the long awn of BC2BIKO with the large glume of 56 x 53, and also to introduce goose-neck into the 56 x 53 material.

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UNITED KINGDOM

Experimental Cultivation of Sorghums in Hampshire, England

J. D. Snowden (New Milton)

In May, 1955, I received fragments of a flowering and fruiting panicle of a Sorghum with the native mane of "Nunaba". It came from the Gambia, West Africa, but had been introduced into that country from Ghana. It was said to have cleistogamous sessile spikelets and it was sent to me for determination. After examination the specimens were considered to be a variety of Sorghum gambicum but differing from those hitherto examined in the ellipticoblong sessile spikelets being 5 - 6.5 mm. long, 2.5 - 3 mm. wide, and having glumes somewhat thinner than usual. It seemed probable that the specimens were the result of intercrossing between S. gambicum and another species, so it was decided to grow a few plants under natural daylight treatment.

A few seeds were sown in an unheated greenhouse at the end of May and the beginning of June, 1955. Some of the plants raised were planted in the open ground, others were grown in pots which were pluged in the soil outdoor, and a few were planted in the border of an unheated greenhouse. All the plants made vigorous growth and were not attacked by any serious pests or diseases. By the end of September the outdoor plants had reached a height of 60 - 75 cm. and the mature leaves were 40 - 70 cm. long and 6 - 5 cm. wide. The culms were 2.5 cm. thick near the base. Those in the greenhouse border attained a height of two meters by October 10 and the mature leaves ranged from 80 - 115 cm. long and 6 - 8 cm. wide. Unfortunately none of the plants showed any indication of forming a flowering panicle.

All the plants left in the open ground, and those in the unheated greenhouse border, died during the winter, although they were protected by felt and sacking. A few of the plants grown in pots were brought into a heated greenhouse at the end of September and these survived the winter. These were grown on and planted out in the open ground at the end of May, 1956. The old culms gradually ceased to develop and were cut out. The ratoon culms grew well in a rather wet and dull season until the end of October. The plants were then 60 - 85 cm. high and the leaves 60 - 90 cm. long and 4.5 - 6 cm. wide, but there were no signs of any of the plants producing a flowering panicle.

The results of the above trials were so discouraging that it seemed useless to continue them. However, after reading "Photoperiodiciteit bij Sorghum vulgare Pers", by Dr. N. C. Keulemans (May, 1958), it was decided to try again in 1960, giving the plants short-day treatment of 10½ hours daylight per twenty-four hours.

Seeds were sown in the greenhouse at the end of April and the middle of May, 1960. Germination was poor, as the seeds were now at least five years old, but a few healthy plants were raised. For convenience they were grown in pots of 3, 5, 8, and 10 inches diameter as growth progressed. When the weather was favorable the plants were stood outdoors, but the season was so wet, dull, and windy, that they had to be kept under glass for the greater part of it. By the end of July the tallest plants were 66 cm. high, the smallest 35 cm., and the average 50 cm. On August 7, the first young panicles were apparent in the sheaths of the flag-leaves and a few days later were bursting through the top of the sheaths.

On August 24, a few flowering spikelets were examined and sketched. The sessile spikelets were elliptic-oblong, 8 - 9 mm. long and 3 - 3.5 mm. wide, with rather thin glumes; the upper lemma had a short mucro up to 2.5 mm. long, some spikelets had 2 and others 3 lodicules; the anthers were 3 - 3.5 mm. long; the young ovary slightly obovate, 1.5 mm. long, and 1.2 mm. wide. This combination of characters clearly indicated a close relationship with Sorghum membranaceum and that the Sorghum under review was a hybrid between it and S. gambicum. A large proportion of the spikelets on the panicles were defective.

A month later some older spikelets were dissected and it was found that the stamens had matured but the ovaries had remained stationary. Throughout the flowering period none of the glumes had opened, so that the spikelets proved to be wholly cleistogamous. The panicles were all rather weak and depauperate, loose and open, averaging 20 cm. long and 5 cm. wide, with the peduncles about 3 mm. thick at the base of the panicle. The average height to the top of the panicle was 70 cm. The average number of leaves, including the small basal ones, was 14, and the mature leaves averaged 43 cm. long and 4 cm. wide. The culms were 12 mm. thick at the base.

The growth of the plants was healthy but not so vigorous as that of the plants grown in 1955 and 1956. This was probably due partly to the plants being grown in pots and partly to the short-day treatment. By the end of September the panicles were showing signs of deterioration and, as no seeds had been formed, the primary culms were cut out to allow the ratoon culms to develop from the base, for observations on their growth during the winter months under greenhouse conditions.

The above results appear to indicate that the "Nunaba" Sorghum may have originated from the intercrossing of a variety of Sorghum membranaceum with one of the local S. gambicum or similar races of the Guineense Group. Although the original specimens sent to me for identification were fertile, their progeny

appeared to be self-sterile, but this may have been partly due to the low temperatures during growth. It is also evident that this Sorghum is very sensitive to the length of daylight per twenty-four hours. Dr. Norman C. Merwine, of State College,Mississippi, according to his article in Sorghum Newsletter, Vol. 3, 1960, page 29, seems to have met with somewhat similar sterility in his experiments with "Nunaba".

In November, 1956, the late Dr. Robert P. Celarier, sent to me a few spikelets of a Sorghum numbered A4830, which he described as "apparently cleistogamous and the leaves seem to be unusually short, and broad." From this description and an examination of the spikelets, the Sorghum was determined as a form of S. aethiopicum var. brevifolium. As a few of the spikelets had stigmas protruding from the glumes it was evident that they were not wholly cleistogamous.

Some of the mature spikelets contained seeds and a few of these were sown in the greenhouse on May 14, 1960. Germination was poor, but several germinated and the plants raised were grown on under the same short-day treatment and conditions as the "Nunaba" Sorghum. The plants grew well but the culms were only 1 - 1.5 mm. thick, and the leaves were about 15 - 18 cm. long and 1 - 1.5 cm wide. By July 16, when the plants were 20 cm. high, and were producing several lateral shoots, the young panicles were seen to be developing within the sheaths of the uppermost leaves. A few days later the spikelets began to emerge from the leaf-sheaths and from time to time during the following days the glumes opened to allow first the stigmas and then the anthers to emerge. The culms and panicles continued their development and by the end of June the plants averaged 50 cm. in height to the top of the panicle. By August 4, the panicles were maturing and some of the spikelets were removed for dissection. From now on there was no further increase in height but panicles were developing on the lateral shoots. As the older culms matured they were removed but the younger clums continued to develop until the end of September and early October.

In habit and leaves these plants agreed with Sorghum virgatum, but the sessile spikelets were elliptic-lanceolate, 9.5 mm. long and 3.5 mm. wide, with coriaceous glumes; the upper lemma with an awn 23 mm. long, and the caryopsis obovate, 3.5 mm. long and 2.5 mm. wide, agreeing well with S. aethiopicum except for having spikelets a little longer than usual. From the above data it would appear that the progeny of Celarier A4830 is a fertile hybrid derived from the two species already mentioned, but it is not cleistogamous. As S. virgatum is a North African species it is probable that this hybrid will prove to be less sensitive to photo-periodicity than the "Nunaba" Sorghum.

During the growing season the mean daily minimum temperatures in the unheated greenhouse, where the plants were kept during the hours of darkness, were: May 54, June 59, July 58, August 58, September 55 degrees Fahrenheit. The mean daily maximum temperatures recorded outdoors at Efford Experimental Horticultural Station, situated about 8 miles away, were: May 62.6, June 67.6, July 65.5, August 65.5, September 64.3 degrees Fahrenheit, and the mean daily sunshine recorded at the same station were: May 6.65, June 9.33, July 5.99, August 5.84, September 6.50 hours. I wish to acknowledge here that I am much indebted to the Director-General,meteorological Office, Air Ministry, London, for permission to publish the above meteorological data from the Efford Station.

From these figures it will be obvious that the temperatures during the growing season were much lower than those prevailing in most countries where Sorghums are grown as a successful cultivated crop. The mean minimum temperatures, however, are very close to those which occur in the highlands of tropical Africa at altitudes of about 1,370 m., for instance in the Mbarara District of Uganda, which is near the highest altitude at which Sorghum verticilliflorum grows spontaneously. In such areas, however, the mean maximum temperatures are about 15 degrees higher than those recorded outdoors at the Efford Station.

I wish to thank Dr. K. F. Shertz and Mr. J. Roy Quinby for sample packets of seeds of Sorghum caffrorum cv. "Texas Blackhull Kafir, F.C. 8962", and S. cernuum cv. "California White Durra, S. A. 208", from Texas Experiment Station, Chillicothe, Texas, received towards the end of July. These arrived too late for a full test in the 1960 season, but a few plants of each have been raised and are being grown in the greenhouse, for their reaction to winter condition to be observed, and further trials will be carried out in the 1961 season.

The Classification and Nomenclature of Sorghum, Section Sorghum

J. D. Snowden

Since my classification of the cultivated Sorghums was published in Kew Bull. 1935, and in "The Cultivated Races of Sorghum" in May, 1936, the new International Code of Nomenclature for Cultivated Plants has come into force and has been generally accepted, it may be helpful to consider how to co-ordinate it with my classification. In order to do this more effectively it seems advisable to give a short summary of the latter for the information of those interested in the cultivated Sorghums who may not be acquainted with it.

Sorghum section Sorghum

This section was formerly known as section Eu-Sorghum, but now the prefix is not necessary. It contains both wild and cultivated Sorghums and it is based on the species originally described by Linnaeus under the genus Holcus, namely H. halepensis, H. sorghum, H. saccharatus, and H. bicolor. Later, when the genus Holcus was divided into several genera by other botanists, these four species were transferred to the genus Sorghum. They are distinguished by the following combination of characters: the leaf-sheaths are glabrous or finely pubescent at the nodes, but are not bearded; the primary branches of the panicle, or at least the lowest, are usually divided; the racemes are lateral and terminal; the number of chromosomes is usually 20 or more.

Section Sorghum is divided into two subsections, namely Halepensia and Arundinacea. The former is based on Holcus halepensis Linn., which on transference to the genus Sorghum became S. halepense (Linn.) Pers. This subsections consists of perennial wild grasses with more or less elongated rhizomes. Many of them have 40 chromosomes. A full account of the species already known was published in the Journ. Linn. Soc. Botany, Vol. LV, pp. 191 - 260, April, 1955. Although some of the species are cultivated as fodder plants, there should be no difficulty in linking up any new cultivated varieties with the names already validly published, whether they are considered as belonging to one collective species under Sorghum halepense or separated under the four races described in the above paper.

Subsection Arundinacea is founded on Andropogon arundinacea Willd., Sp. Pl. IV, 906, 1805, which under Sorghum became S. arundinaceum (Desv.) Stapf. The sorghums of this subsection are either annuals, or may persist for several seasons as tufted perennials without rhizomes, owing to secondary culms arising from the buds at the base of the old parent culm. Most of them have 20 chromosomes. This subsection is divided into two series, Spontanea and Sativa. The series Spontanea consists of wild grasses with fragile racemes which break up at maturity so that the sessile spikelets are deciduous and fall off when mature together with the adjoining pedicelled spikelet or its pedicel. The grains are usually small and entirely enclosed by the glumes. The species of this series are also fully described in the above publication and the names of any new cultivated varieties can quite easily be added to them.

The series Sativa is the one with which this paper is mostly concerned, as it embraces the cultivated grain sorghums, as well as the sweet-stemmed or sugar sorghums and the broomcorn sorghums. The sorghums of this series are characterized by having tough racemes which do not break-up at maturity, the sessile spikelets remaining on the panicle, with or without the pedicelled spikelets, thus enabling the panicles to be harvested together with the mature grains, which are generally large and often exceed the glumes in size, being usually much exposed, but sometimes enclosed by the glumes. This series is based on three of the Linnean species already mentioned, namely Holcus sorghum, H. saccharatus, and H. bicolor.

During the following one and a half centuries many new species and varieties of cultivated sorghums were described and they were classified in various ways. Some botanists continued to give specific rank to the more distinct races, but others treated them as subspecies or varieties of one huge species. In dealing with the vast amount of material gathered together in the Kew Herbarium, during the years following Stapf's revision of the Tropical African Sorghums (Prain, Fl. Trop. Afr. IX, 104-154: 1917), I decided to follow his example and divide them into a number of distinct species. The cultivated sorghums of the series Sativa were divided into six subseries and thirty-one species. The separation of these was based mainly on the characters of the sessile spikelets and racemes, and especially on the size and shape of the sessile spikelets when in flower and in fruit, combined with the texture of the glumes and the length of the pedicals of the pedicelled spikelets. Subsidiary characters such as size, shape, density and erectness of the panicle; size, shape and color of the grains; and insipidness or sweetness of the culms; were used to separate the varieties within the species.

With so much material, gathered from so many parts of the world, the composition of a workable key to the species was very difficult, especially as there was usually a certain amount of variation in the characters of many species. However, after a very careful re-examination of the original key to the subseries and species published in "The Cultivated Races of Sorghum", I have been able to make only a few minor amendments to it. They include the addition of a few common names for the subseries. The amended key is given below and as it differs so little from the original, I wish to record my due acknowledgements to the Bentham-Moxon Trust and to the publishers, Messrs. Adlard and Son, Limited. For keys to the varieties, full descriptions of the species and varieties, as well as information concerning their relationships, history, and early classification, etc., reference should be made to "The Cultivated Races of Sorghum". Copies of the original are still available from the Royal Botanic Gardens, Kew, price 10/6.

Key to the cultivated races of Sorghum section Sorghum series Sativa.

A. Sessile spikelets twice as long as broad or longer when in flower (with the glumes closed), broadest about the middle or below the middle, more or less lanceolate to elliptic, ovate, or oblong:

b. Glumes of the sessile spikelets usually tough and coriaceous, with the nerves exteriorly visable only near the tips; pedicals of the pedicelled spikelets and internodes of the racemes comparatively long and slender, usually 2-4 mm. long; panicles mostly loose, sometimes contracted but not densely compact:

c. Sessile spikelets with the glumes closed or almost closed when mature; mature grains usually small, shorter than and tightly embraced by the glumes: Subseries i. Drummondii or "Chicken Corn" Group.

d. Pedicelled spikelets readily deciduous when mature; sessile spikelets 2-2.5 mm. wide, 4.5-5.5 mm. long when in flower, lanceolate to elliptic-lanceolate or narrowly elliptic; upper lemma awned or mucronate; grains elliptic to abovate-elliptic. . . 1. <u>S. aterrimum</u> Stapf

dd. Pedicelled spikelets usually persistent, rarely tardily deciduous; sessile spikelets 2.5-3mm. wide, 5-6 mm. long when in flower:

e. Sessile spikelets oblong-lanceolate to elliptic or ovate-elliptic; upper lemma awned; grains broadly elliptic to elliptic-rotund, almost as wide as long . . . 2. <u>S. drummondii</u> (Steud) Millspaugh et Chase

ee. Sessile spikelets elliptic-lanceolate; upper lemma mucronate; grains elliptic, distinctly longer than wide . . . 3. <u>S. nitens</u> (Busse et Pilger) Snowden

cc. Sessile spikelets with the glumes opening more or less widely when mature, so that the grains are usually much exposed: Subseries ii. Guineensia or "Guinea Corn" Group

f. Mature grains often shorter and usually not longer than the glumes:

g. Pedicelled spikelets deciduous when mature; lower glume of the sessile spikelets with the keels usually marginate (minutely winged) in the upper part and terminating in minute teeth so that the tip is more or less 3-toothed; mature grains usually much exposed between the widely gaping glumes; panicles usually glabrous in appearance owing to the hairs being short and sparse:

h. Sessile spikelets 4.5 - 6 mm. long, lanceolate to elliptic- or oblong-lanceolate, obtuse or shortly acute, 2.5 - 3 mm. wide when in fruit; lower glume with the terminal tooth about as long as the lateral ones; upper lemma usually long-awned; mature grains 3 - 4.5 mm. long, 2.5 - 3 mm. wide, biconvex or slightly compressed, shorter than the glumes . . 4. <u>S. margaritiferum</u> Stapf

hh. Sessile spikelets 5 - 7.5 mm. long, elliptic-oblong to elliptic-ovate, acute to acuminate, 3 - 4 mm. wide when in fruit; lower glume with the terminal tooth decidedly longer than the lateral teeth; upper lemma mostly mucronate but sometimes awned; mature grains 4 - 6.5 mm. long, 3 - 5.5 mm. wide mostly flattened and much compressed, as long as or shorter than the glumes. . .5. <u>S. guineense</u> Stapf

gg. Pedicelled spikelets usually persistent when mature; panicles generally more or less hairy in appearance owing to the hairs being conspicuous and abundant, less often glabrescent:

i. Lower glume of the sessile spikelets with the keels marginate from just above the middle or with the keel-nerves scabrid, often terminating in minute teeth; sessile spikelets elliptic to elliptic-ovate, acute, 5 - 6.5 mm. long, 3 - 3.5 mm. wide when in fruit; upper lemma awned or mucronate; mature grains 3.5 - 4.5 mm. long, biconvex or flattened on the face, classed by one or both glumes; panicles hairy or sometimes glabrescent; culms sweet . . . 6. <u>S. mellitum</u> Snowden

ii. Lower glume of the sessile spikelets with the keels smooth and not marginate, or only shortly marginate near the tip; panicles usually hairy in appearance:

j. Sessile spikelets acute or acuminate, 5 - 7.5 mm. long, 3 - 4.5 mm. wide when in fruit and then mostly glabrescent, elliptic- to oblong-lanceolate or elliptic; upper lemma mostly awned; mature grains much compressed and flattened, 5 - 6.5 mm. long, much exposed between, and not longer than, the widely gaping glumes . . . 7. S. conspicum Snowden

jj. Sessile spikelets finely acute to acuminate, 4 - 6 mm. long, 3 - 3.5 mm. wide when in fruit, lanceolate to ovate-lanceolate or ovate, permanently hairy or less often glabrescent; upper lemma usually mucronate, rarely awned; grains biconvex or only slightly compressed, usually shorter but sometimes longer than the glumes, much exposed or less often clasped by one or both glumes . . . 8. S. roxburghii Stapf

ff. Mature grains exceeding the glumes in length; sessile spikelets narrowly elliptic to elliptic-oblong; upper lemma mucronate or awned:

k. Mature grains readily falling from the gaping glumes, more or less compressed and flattened; sessile spikelets 4 - 5 (rarely 5.5) mm. long, 2 - 2.5 mm. wide when in flower; pedicelled spikelets persistent: . . . 9. S. gambicum Snowden

kk. Mature glumes usually clasped below by the shorter glumes, rarely looser, mostly biconvex but sometimes slightly compressed; sessile spikelets 4.5 - 6 mm. long, 2.5 - 3 mm. wide when in flower; pedicelled spikelets deciduous or sometimes persistent . . . 10. S. esertum Snowden

bb. Glumes of the sessile spikelets, or at least the lower, papery or thinly crustaceous with the nerves externally visible to the middle or below the middle, rarely with the nerves obscure except in the upper third (S. ankolib); pedicelled spikelets usually persistent, rarely almost suppressed; Subseries iii. Nervosa, "Prominently Nerved" or "kaoliang" Group.

l. Sessile spikelets with one or both glumes thin and papery almost throughout; elliptic, elliptic-oblong or oblong:

m. Both glumes usually papery throughout or sometimes subcoriaceous in the lower half; sessile spikelets 6 - 11 (rarely 5) mm. long; mature grains shorter than the glumes, entirely enclosed or at length exposed at the top; pedicels of the pedicelled spikelets 1 - 4 mm. long . . . 11. S. membranaceum Chiov.

mm. Lower glume thin and papery throughout; upper glume thinly coriaceous; mature grains usually much exposed; pedicels of the pedicelled spikelets 1-2 mm. long:

n. Sessile spikelets 6 - 7 mm. long, 2.5 - 3 mm. wide when in flower; lower glume finely nerved; mature grains 5 - 5.5 mm. long, not protruding beyond the glumes but more or less exposed . . 12. S. basutorum Snowden

nn. Sessile spikelets 4 - 5 mm. long, 2.25 - 2.5 mm. wide when in flower; lower glume strongly striately nerved throughout or smoother and slightly gibbous near the base; mature grains 3.5 - 5.5 mm. long, often much exposed and protruding beyond glumes...13. S.nervosum Bess. ex Schult.

11. Sessile spikelets with the glumes thinly crustaceous almost throughout, or sometimes subcoriaceous in the lower third or two-thirds (S. ankolib); grains as long as or shorter than the glumes:

o. Sessile spikelets 6 - 7 mm. long, elliptic-oblong to oblong; glumes opening more or less widely when mature, striately nerved to the middle or below the middle; upper lemma mucronate or with a short awn; mature grains much exposed; pedicels of the pedicelled spikelets 1 - 2 mm. long. . . 14. S. meleleucum Stapf

oo. Sessile spikelets with the glumes remaining closed or almost closed when mature.

p. Sessile spikelets 6 - 7.5 mm. long, elliptic to elliptic-oblong or broadly elliptic to broadly elliptic-oblong, with the glumes thin in the upper half or third; upper lemma usually mucronate; pedicelled spikelets large; pedicels 0.5 - 1 mm. long . . .15. S. ankolib Stapf

pp. Sessile spikelets 6 - 11 mm. long, elliptic- to oblong-lanceolate or elliptic to oblong; glumes thinly crustaceous and striately nerved to the middle of below the middle; upper lemma usually awned; pedicelled spikelets large or often reduced, rarely almost suppressed; pedicels slender, 2 - 4 mm. long. . . 16. S. splendidum (Hack.) Snowden

AA. Sessile spikelets usually less than twice as long as broad when in flower, broadly ovate to broadly elliptic, broadly elliptic-oblong and rotundate, or obovate-elliptic ot obovate-oblong, obovate and obovate-rotund, or rhomboid to hexagonous, often broadest above the middle; pedicels of the pedicelled spikelets usually 0.5 - 2 mm. long, but sometimes longer in S. dochna, S. notabile, S. coriaceum, and S. rigidum:

B. Lower glume of the sessile spikelets usually coriaceous almost throughout with the nerves externally visible only near the tip when in flower, sometimes crustaceous and somewhat striately nerved to the middle (S. dochna) but then the mature grains enclosed or almost enclosed by the glumes:

C. Sessile spikelets mostly obovate-elliptic to obovate, obovate-oblong, obovate-rotund or rhomboid, less often broadly elliptic or elliptic-oblong when in flower, but then becoming obovate-elliptic to obovate-oblong when in fruit; panicles usually loose and comparatively glabrous in appearance; mature grains enclosed or almost enclosed, less often more exposed but then tightly clasped below by the glumes: Subseries iv. Bicolor or "Sugar" and "Broomcorn" Sorghum Group.

D. Glumes of the sessile spikelets often rather thin and somewhat crustaceous when mature, the lower with the tip not depressed, sometimes finely striately nerved to the middle or below the middle; sessile spikelets 4 - 6 (rarely 7) mm. long, 2 - 3 mm. wide when in flower, broadly elliptic to elliptic-oblong or slightly obovate-elliptic to obovate-oblong: upper lemma mostly awned; mature grains similar in shape and size to the sessile spikelets, wholly enclosed or only slightly exposed . . 17. S. dochna (Forsk.) Snowden

DD. Glumes of the sessile spikelets coriaceous almost throughout with the nerves externally obscure except near the tip:

E. Glumes of the sessile spikelets almost closed; when mature and the equally long grains with only a little of the top exposed, or less often with the grains more exposed but then with the tip of the lower glume depressed and hairy when in flower:

F. Sessile spikelets broadly obovate, 4 - 6 mm. long, 3 - 4 mm. wide when in flower, sometimes obovate-rotund to subglobose when in fruit; upper lemma awned; mature grains 3 - 4.5 mm. long, 2.5 - 4 mm. wide, like the spikelets in shape, enclosed or more often exposed at the top. . . 18. S. bicolor (Linn.) Moench

FF. Sessile spikelets obovate-rotund to obovate-oblong, 3 - 3.5 mm. long, 2.5 - 3 mm. wide when in flower; upper lemma mucronate; mature grains exposed at the top or sometimes almost to the middle, subglobose, 3 - 4 mm. long and wide. 19. S. miliiforme (Hack.) Snowden

EE. Glumes of the sessile spikelets opening to expose one-third to one-half of the often much longer grains, tip of the lower glume glabrous or almost glabrous like the rest of the spikelet; upper lemma mostly mucronate:

G. Sessile spikelets with the tip of the lower glume distinctly more or less depressed, obovate-oblong to obovate, 4 - 5 mm. long; mature grains equalling or scarcely longer than the glumes, 4 - 4.5 mm. long, exposed for about one-third of their length, biconvex but bulging more on the back than on the face, elliptic in outline with a rather pointed apex. . . 20. S. simulans Snowden

GG. Sessile spikelets with the tip of the lower glume not or scarcely depressed when in flower, 3.5 - 5.5 mm. long; mature grains usually much longer than the glumes, exposed for one-third to one-half of their length:

H. Sessile spikelets 3 - 3.5 mm. wide when in flower, broadly obovate-elliptic to obovate or rhomboid; mature grains 3.5 - 6 mm. long, 3 - 5 mm. wide; pedicelled spikelets persistent. . . 21. S. elegans (Koern.) Snowden

HH. Sessile spikelets 2 - 3 mm. wide when in flower, elliptic or elliptic-oblong to slightly obovate or narrowly obovate-oblong; mature grains 5 - 6.5 mm. long, 3 - 4.5 mm. wide; pedicelled spikelets mostly deciduous but sometimes persistent. . . 22. S. notabile Snowden

CC. Sessile spikelets more or less broadly ovate to broadly elliptic, broadly oblong and rotundate, or obovate-oblong, obovate-elliptic or obovate-rotund and often not much longer than wide when in flower, with the glumes opening to expose one-third to one-half of the grain when mature; mature grains as long as, or more usually much exceeding the more or less adpressed glumes; panicles contracted and dense to compact, or sometimes looser but then, as usual, with the rachis branches and branchlets hairy to villous; pedicels of the pedicelled spikelets usually 0.5 - 2 mm. long, but sometimes a little longer in S. coriaceum and S. caudatum:

Subseries Caffra, or "Kafir Corn" and "Bantu Sorghum" Group.

I. Sessile spikelets broadly ovate to broadly elliptic, hairy to villous, at least when young; pedicelled spikelets persistent; grains biconvex or only slightly compressed, 3.5 - 6 mm. long.

J. Upper lemma of the sessile spikelets usually with a long awn, rarely mucronate sessile spikelets broadly elliptic, 4 - 6.5 mm. long, 2.5 - 3.5 mm. wide when in flower . . . 23. S. coriaceum Snowden

JJ. Upper lemma of the sessile spikelets usually mucronate, rarely with a short awn; sessile spikelets elliptic-ovate to elliptic-rotund or ovate, 3 - 5.5 mm. long, 2 - 3 mm. wide when in flower. . . 24. S. caffrorum Beauv.

II. Sessile spikelets broadly elliptic or broadly oblong to broadly obovate-elliptic, obovate-oblong or obovate-rotund:

K. Mature grains usually much protruding beyond the glumes and clasped by both of them; pedicelled spikelets persistent or deciduous:

L. Sessile spikelets 2.5 - 3.5 mm. long, broadly oblong to obovate-oblong or obovate-rotund, sparsely hairy or glabrescent; upper lemma mucronate or seldom with a short awn; grains predominantly biconvex with a broad subspherical top, 3 - 4 (rarely 4.5) mm. long and broad. . . 25. S. nigricans (Ruiz et Pavon) Snowden

LL. Sessile spikelets 3.5 - 5.5 mm. long, elliptic-oblong to abovate-elliptic or obovate-oblong, hairy or almost glabrous; upper lemma usually mucronate; grains mostly bulging on the back but flattened on the face, rarely biconvex, 3.5 - 6 mm. long, 3 - 5 mm. wide. . . 26. S. caudatum Stapf

KK. Mature grains not protruding beyond the somewhat gaping glumes, 4 - 4.5 mm. long, 3 - 3.75 mm. wide, somewhat flattened on the face, bulging on the back; sessile spikelets 4 - 5 mm. long, obovate-elliptic or obovate-oblong, somewhat coarsely hairy; upper lemma mucronate; pedicelled spikelets persistent. . . 27. S. dulcicaule Snowden

BB. Lower glume of the sessile spikelets either with a large strong nerved somewhat herbaceous tip but otherwise coriaceous, or thin and somewhat transversely wrinkled and depressed about the middle with the remainder spongy or coriaceous when in flower; sessile spikelets broadly ovate to broadly elliptic, obovate-oblong, rhomboid or almost hexagonal; mature grains as long as or more often longer than the glumes (except S. rigidum); pedicelled spikelets large and often male:

vi. Subseries Durra, or "Durra," "White Durra", and "Milo" Group.

M. Pedicelled spikelets deciduous, pedicels 3 - 5 mm. long; sessile spikelets 6 - 8 mm. long, 3.5 - 4 mm. wide when in flower, broadly elliptic to obovate-elliptic or obovate, almost glabrous; glumes coriaceous in the lower two-thirds; upper lemma with an awn up to 14 mm. long; mature grains 5 - 5.5 mm. long, 4.75 - 5 mm. wide, almost enclosed or with the broad tops exposed between the brittle glume-tips; panicle somewhat contracted and rigid, glabrous in appearance. . . 28. S. rigidum Snowden

MM. Pedicelled spikelets persistent, pedicels 0.5 - 2 mm. long; sessile spikelets 4 - 6 mm. long; upper lemma awned or mucronate; panicles mostly dense and compact but sometimes loose; rachis and branchlets tomentose to villous:

N. Lower glume of the sessile spikelets coriaceous up to or above the middle and with a large strongly nerved tip, not transversely wrinkled or depressed above the middle; sessile spikelets obovate-elliptic, obovate-oblong, obovate or rhomboid, 2.5 - 4.5 mm. wide when in flower, up to 6 mm. wide when in fruit; mature grains 4 - 6 mm. long, 2.5 - 6 mm. wide, biconvex, often with a broad top, usually much protruding beyond the glumes. . . 29. S. durra Stapf

NN. Lower glume of the sessile spikelets either somewhat thin and transversely wrinkled and depressed about the middle or somewhat soft and spongy in the lower half and then more or less villous and with the grains compressed; upper lemma mostly awned but sometimes mucronate:

O. Sessile spikelets broadly ovate to slightly obovate, 3 - 4 mm. wide when in flower, usually permanently whitish, villous or at length glabrescent on the thicker portion of the glumes; mature grains subrotund to orbicular, usually much compressed and flattened, more or less exposed . . .30. S. cernuum Host

OO. Sessile spikelets oblong to obovate-oblong, broadly obovate-oblong or somewhat hexagonal, 2 - 3 (rarely 4) mm. wide when in flower, somewhat hairy when young but at length glabrescent or sparsely strigose; mature grains much exposed, usually broad and subspherical at the top with the base more or less compressed and wedge-shaped. . . 31. S. subglabrescens Schweinf. et Aschers.

Under the new International Code of Nomenclature all the bontanical names in the foregoing classification and key that were validly published will continue to be available for use. In my opinion the retention of specific names for the more distict races of Sorghum continues to remain the most satisfactory system of dealing with them, not only for the purpose of facilitating their identification and arrangement in herbaria, but also to help in tracing their origin and history, as well as to indicate their relationships where genetical work is being carried out. Some examples of the way in which my classification can be brought in line and used with the new Code are, therefore, given below:

The main grouping of the cultivated Sorghums should be placed under the heading: Sorghum sect. Sorghum ser. Sativa.

The species and varieties may then be placed either under the subseries (or Groups) or under the particular species followed by the varieties or cultivarieties: Subser. Guineensia (S. roxburgii) var. hians; or "Shallu".
Subser. Caffra (S. caffrorum) var. albofuscum; or "Pink Kafir."
Subser. Bicolor (S. dochna) var. mellitum; or "Miller" or "Broom Corn"
Subser. Durra (S. cernuum) var. truchmenorum; or "Jerusalem Corn."

Or the name of the subseries or group could be omitted and the specific name used: Sorghum (guineense) var. involutum; or "Farfara."
Sorghum (caudatum) var. kerstingianum; or "Jar Dawa."
Sorghum (bicolor) var. piciguttai; or "Maryland Mammoth."
Sorghum (durra) var. aegyptiacum; or "Gasabi."

Where a variety and its relationship is well established and widely recognized it could be used without inserting the names of some of the subsidiary groups as: Sorghum (sect. Sorghum) var. feterita, or
Sorghum (sect. Sorghum) "Dwarf Kafir."

The names included in the brackets may be omitted where they are considered unnecessary, as Sorghum "Blackhull Kafir."

Agriculturists, commercial seed growers, and some botanists may prefer to treat the cultivated Sorghums as varieties of one comprehensive species, in which case the subseries could be termed groups and the species of which, as species of Sorghum sect. Sorghum. The use of Sorghum vulgare Pers. for such a purpose should be gradually discontinued, as I am informed that this name is illegitimate. Here I wish to express my thanks to Mr. A. A. Bullock, one of the Principal Scientific Officers in the Kew Herbarium for investigating this matter and for his permission to publish his review of it as an appendix to this paper.

Sorghum vulgare Persoon

A. A. Bullock (Kew)

The nomenclatural principles employed in deciding upon the correct name for the species to which Persoon applied the illegitimate name Sorghum vulgare are of some interest, and demonstrate the operation of a number of articles of the International Code of Botanical Nomenclature. The 1956 (Paris 1954) edition of the Code is quoted below, and although the article numbers may be changed as a result of the Montreal (1959) Congress, their contents will remain substantially the same.

Holcus sorghum Linn. (Sp. Pl. 1047. 1753) was divided into two species by Linnaeus, and he retained the name for one of them, thereby narrowing the field for lectotypification of both H. sorghum and the new segregate species H. bicolor Linn. (Mant. alt. 301. 1771) . The two names are legitimate under the terms of Articles 51 and 53.

J. Gaertner (Fr. et Sem. Pl. 2: 4. t.80. 1791) included H. bicolor Linn. in H. sorghum Linn. as a variety. He also added another variety to which he applied the binomial "H. rubens." An adequate definition of the last was given, but Gaertner did not make the names in accordance with Article 24 and "H. rubens" was not validly published as either a varietal or a specific name. The correct form for the names of the three entities, to insure valid publication, would be H. sorghum Linn. var. sorghum, H. sorghum Linn. var. bicolor (Linn.) J. Gaertner and H. sorghum Linn. var. rubens J. Gaertner. These three entities together constitute a particular circumscription of H. sorghum Linn. which is the correct name for it under Article 25 ("a species . . . is regarded as the sum of its subordinate taxa") and Article 57.

The genus Sorghum was segregated from Holcus and described by Moench (Meth.. Pl. 208: 1894). His circumscription of the genus included two species, namely S. bicolor (Linn.). Moench. and S. saccharatum (Linn.) Moench, based respectively upon Holcus bicolor Linn. and H. saccharatus Linn. It is unfortunate that Moench did not mention Holcus sorghum Linn., and it cannot be assumed that he intended it to be included under S. bicolor.

Persoon (Syn. Pl. 1: 101. 1805) accepted the genus Sorghum Moench, and Gaertner's circumscription of Holcus sorghum Linn., which had reduced H. bicolor Linn. to varietal rank. Avoiding the tautonym "Sorghum sorghum" in accordance with Article 70 (4) he provided the new name Sorghum vulgare Pers. Since this included (Article 25) S. bicolor (Linn.) Moench, it was superfluous and hence illegitimate under Article 64 (1). The correct name for the species with Persoon's circumscription is undoubtedly Sorghum bicolor (Linn.) Moench, the type of which is the same as the type of Holcus bicolor Linn.

It is necessary, finally, to examine the situation if Holcus bicolor Linn. and H. sorghum are again separated as species distinct from each other. This is of course a matter of taxonomic opinion, and there are three possibilities:

(a) if Holcus sorghum stands alone, without synonyms, it will require a new epithet on transference to the genus Sorghum (Articles 55, 70, 72), since S. vulgare Pers. is illegitimate; (b) if Holcus sorghum is united with other species without legitimate names, it will still require a new epithet on transference to Sorghum; (c) if Holcus sorghum is united with other species with an available legitimate name, it will merely remain in synonymy and will not require an epithet under the genetic name Sorghum (Articles 55, 57). The last of these is in fact the fate of H. sorghum; it is a synonym of Sorghum cernuum (Arduino) Host.

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